Washington Natural Gas
A Washington Energy Company

Tacoma Historical Coal Gasification Site

Inspection and Maintenance Manual

August 1995

EBASCO ENVIRONMENTAL

FOSTER WHEELER ENVIRONMENTAL CORPORATION

August 14, 1995
FWBEL-WNGC/A-L-95-019

Mr. Lee Marshall - Project Coordinator
U.S. Environmental Protection Agency
1200 Sixth Avenue
(11th Floor Superfund Office)
Seattle, WA 98101

Subject: **Washington Natural Gas Company**
Tacoma Historical Coal Gasification Site
Inspection and Maintenance Manual

Dear Mr. Marshall:

Enclosed you will find two copies of the Inspection and Maintenance Manual. The manual is revised to incorporate your comments received. If you have any questions please call me at (206) 688-3914 or Satendra Jain at (206) 688-3710.

Sincerely,

Foster Wheeler Environmental

Amadeo J. Rossi
Environmental Site Supervisor

w/att: Inspection and Maintenance Manual

cc w/att:
D. Holsten - CH2M Hill (2 copies)
M. Dalton - Dalton, Olmstead & Fuglevand, Inc. (1 copy)
B. Grant - Raytheon (2 copies)
K. Daugherty - WNGC (3 copies)
S. Jain - Foster Wheeler Environmental (1 copy)
B. Zbitnoff - Foster Wheeler Environmental (1 copy)
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

Reply To
Attn of: HW-113

FEB 27 1996

Mr. Matthew Dalton
Dalton, Olmsted & Fuglevand, Inc.
19017 120th Ave N.E., Ste 107
Bothell, WA 98011

Re: Tacoma Tar Pits Inspection Maintenance Manual

Dear Mr. Dalton:

This letter is a follow-up to our telephone conversation of 2/26/96. As discussed, the I&M manual has an error on Page 3 regarding the number of years that the inspection and maintenance will be carried out by WNG. The first sentence in the last paragraph should read "The property will be maintained by WNGC for 30 years."

Please correct the typo in your copy. We will amend our copies accordingly.

If you have any questions, please feel free to call me.

Sincerely,

Lee Marshall

cc: Kaaren Daugherty, WNG

INSPECTION AND MAINTENANCE MANUAL

FOR THE TACOMA HISTORICAL COAL GASIFICATION SITE

REMEDIATION

PREPARED FOR

WASHINGTON NATURAL GAS COMPANY

BY

EBASCO ENVIRONMENTAL

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MANUAL ORGANIZATION

This Inspection and Maintenance Manual is divided into two parts: organizational and technical.

Sections 1.0 through 5.0 of the text provides the organizational framework for carrying out the Inspection and Maintenance Program for the Tacoma Historical Coal Gasification Site (THCGS). It identifies the parties responsible for the Program, and describes the development of procedures for inspections and repairs, schedules of inspections and repairs, recordkeeping, evaluation of inspection results (including basic acceptance criteria) and performance of maintenance and repair work.

Sections 6.0 through 11.0 provide the technical requirements for performance of inspection and maintenance.

Appendix A contains inspection and maintenance record forms for the drainage features, concrete and asphalt surfaces, and waste pile cover.

Appendix C contains test specifications.

Appendices B and D through F contain manufacturer's catalog cuts of recommended materials for use in maintenance and repairs.

1.0 PROGRAM REQUIREMENTS

The Inspection and Maintenance (I&M) Program for the THCGS covers inspection, testing and repairs for the functional features of the remediation, which include the asphalt and concrete pavements, the vegetated waste pile cover and various drainage systems. The Program defines the performance requirements to be achieved, identifies the parties responsible to carry out the program and the methods of achieving the performance requirements. This I&M Manual was prepared on behalf of Washington Natural Gas Company (WNGC). The Manual was reviewed, revised, and approved by the U.S. Environmental Protection Agency (EPA), Department of Ecology and JS&S prior to implementation.

Post remediation groundwater sampling, monitoring well I&M, associated health and safety procedures, and potential corrective action for groundwater will be described in a separate plan (Post Remediation Ground Water Monitoring Plan) to be submitted later to the EPA for review and approval.

1.1 SYSTEM DESCRIPTION AND GENERAL PERFORMANCE REQUIREMENTS

The purpose of the cover system is to isolate the underlying stabilized waste materials from the surface environment and minimize infiltration of surface water into the subsurface. The cover system at the THCGS consists of several components which are described below. The primary site features are shown on Figures 2 and 3.

Waste Pile Cover - This component covers stabilized waste and is a "hybrid cover" of grass, soil, and geosynthetic fabrics. The purpose of this cover is to prevent physical disturbance (e.g. erosion) of the stabilized materials and minimize the potential for water to contact the underlying materials.

Waste Pile Drainage System - The drainage system for the waste pile consists of lined open ditches and box culverts which channel water to Detention Basin No. 1 prior to discharge into the Burlington Northern Railroad (BNRR) ditch. The Detention Basin is lined with low permeability asphalt.

Metal Recycling Area Cover - The cover in the metal recycling area consists of concrete and asphalt. The purpose of the cover is to minimize the potential for water to infiltrate into

the underlying soils and to allow metal recycling operations to continue. The asphalt consists of two layers; a low permeability layer covered by a more permeable but more durable layer.

Metal Recycling Drainage System - The drainage system in the recycling area consists of a series of catch basins, man-holes, and buried concrete pipe which divert water into Detention Basin No. 2 prior to discharge. The detention basin is lined with low permeability asphalt.

The surface of the remediated area of the THCGS shall be maintained so as to preserve its integrity and continuity over the entire area. Conditions which impair the integrity and continuity of the surface shall be detected and the defects repaired.

Positive slopes shall be maintained over all surfaces to allow water to drain freely without ponding.

The drainage systems remove storm water from the remediated portion of the THCGS. The catch basins, piping, BNRR Ditch and Waste Pile perimeter ditches shall be kept clean and available to perform this function. Piping joints shall be tight and pipes free of defects. Leak tightness of the systems shall be verified by standard test methods specified hereinafter.

1.2 RESPONSIBILITY FOR PROGRAM EXECUTION

WNGC shall be responsible for the execution of the inspection requirements set forth in this I&M Plan for the indicated periods.

The responsibility for the maintenance and repair requirements of the JS&S property shall be divided between JS&S and WNGC. JS&S shall be responsible for repairs of damage, routine maintenance, and/or wear caused by its operations on its property. WNGC will be responsible for other maintenance associated with the remediation work performed by WNGC or repair requirements due to design or construction deficiencies.

The remaining property will be maintained by WNGC for 20 years. The inspection summary table following this page defines the scope of inspections. The agreed schedule shall be revised from time to time as conditions warrant and the revisions provided to the Parties, and the EPA.

When it is determined based on evaluation of a reported condition that maintenance or repair is required, a recommendation will be prepared to perform work. The recommendation will be prepared in writing by the person or persons performing the evaluation and will be reviewed by the Parties and by the EPA.

INSPECTION SUMMARY TABLE
TACOMA HISTORICAL COAL GASIFICATION SITE

Maintenance Item	Inspection Schedule	Inspection Items (Section)
JS&S Drainage System (JS&S operating areas and Detention Basin 2)	• Twice in the first year • Annually thereafter • Observe for flow in manhole end of dry season • Unscheduled inspections will be made after periods of heavy precipitation	• Detention Basin 2 (4.3, 8.1) • Control Structures (8.1) • Flow Restrictors (8.1) • Pipes (8.1) • Catch Basins and Manholes (8.1)
WNGC Drainage System	• Twice in the first year • Annually thereafter • Unscheduled inspections will be made after periods of heavy precipitation	• Detention Basin 1 (3.3.1, 8.1) • Control Structures (8.1) • Flow Restrictors (8.1) • Pipes (8.1) • Open Ditches (8.1)
Waste Pile Cover Drainage and Turf	• Inspections should take place 5 days after mowing • Monthly for the first wet season • Then every six months • Unscheduled inspections will be made after periods of heavy precipitation	• Development of topsoil cracks (3.1.1.1, 3.1.2.3) • Bare areas (3.1.1.2, 3.1.2.2) • Surface erosion (3.1.1.2, 3.1.2.5) • Mowing (3.1.1.2, 3.1.2.1)
JS&S Asphalt and Concrete Pavements	• Twice during the first year • Thereafter annually • Hydraulic conductivity testing performed at 5-year intervals (asphalt only)	• Erosion (6.1, 6.2.5, 10.3, 10.4.3) • Abrasion (6.1, 6.2.5, 10.3, 10.4.3) • Cracking (6.1, 6.2.1, 10.3, 10.4.1) • Settlement (6.1, 6.2.2, 10.3)
WNGC Asphalt Pavement	• Twice during the first year • Thereafter annually • Hydraulic conductivity testing performed at 5-year intervals	• Erosion (6.1, 6.2.5) • Abrasion (6.1, 6.2.5) • Cracking (6.1, 6.2.1) • Settlement (6.1, 6.2.2)

1.3 SUPPORTING DOCUMENTATION

The work to be inspected and maintained under this program will be defined in the project closure report. This report will consist of the original design documentation revised to incorporate changes made during remediation.

Revisions to the Program and to the Procedures in this Manual may be made from time to time by WNGC as conditions warrant. Revisions to this Manual will be furnished to the Parties, including the EPA and the Washington Department of Ecology, for review prior to implementation.

WNGC shall approve all Procedures and revised Procedures prior to their use.

2.0 TRAINING

2.1 INSPECTORS

Inspectors shall be knowledgeable of the inspection criteria and maintenance procedures of the vegetated waste pile cover, pavements, and permanent stormwater drainage facilities as described in this manual. The primary means of inspection shall be visual observations. The inspectors shall be familiar with the types of problems that may occur such as types of cracking. Thorough knowledge of asphalt pavement condition rating techniques such as that contained in the Asphalt Institute Information Series No. 169 (IS-169), "A Pavement Rating System for Low-Volume Asphalt Roads" and a thorough knowledge of concrete pavement condition rating techniques such as that contained in the ACI Journal May 1986, "Guide for Making a Condition Survey of Concrete Pavements" shall be required. It is essential for inspection personnel to have a thorough understanding of the operation of the installed stormwater drainage system including the operation of the flow control structures. Personnel shall be trained to keep accurate records and documentation of field observations including photographic and videotape visual observation techniques. A thorough knowledge of the objectives of this inspection and maintenance program is required.

2.2 MAINTENANCE WORKERS

All personnel performing maintenance and repair work in accordance with the Procedures prescribed by the Inspection and Maintenance Program shall be qualified to perform repairs in accordance with the applicable repair procedures. The personnel shall be experienced in all aspects of turf maintenance including mowing, erosion control, mechanical weed control, reseeding, mulching, and fertilizer and lime application. The personnel shall also be experienced in the repair of geonet, high density polyethylene (HDPE) membrane, geosynthetic clay liner and geotextile. The personnel shall be experienced in the cleaning and repair of storm drainage systems and ditches. The personnel shall be experienced in the cleaning, removal, patching, crack sealing, surface sealing, joint sealing, resurfacing, overlaying, and sawcutting of asphalt and concrete pavements.

3.0 WASTE PILE AREA

3.1 WASTE PILE COVER

The waste pile cover consists of 2 different sections. One section is installed on the relatively flat top of the waste pile. The second section is used on the 3 horizontal to 1 vertical (3H:1V) side slopes. The following is a description of the cover system beginning with the base layer.

a. Top of Waste Pile Cover
   1) A geotextile place directly on the prepared waste pile surface.
   2) A geosynthetic clay layer placed on the geotextile.
   3) A minimum 60 mil. thick HDPE geomembrane textured on both sides.
   4) A multilayer geosynthetic composite consisting of a geotextile bonded to both sides of a geonet.

b. Side Slopes of Waste Pile Cover
   1) A geotextile placed directly on the prepared waste pile surface.
   2) A minimum 60 mil. thick HDPE geomembrane placed on the geotextile.
   3) A multilayer geosynthetic composite consisting of a geotextile bonded to both sides of a geonet.
   4) An HDPE geomembrane as described above.
   5) A geosynthetic composite as described in 3) above.

Above the geosynthetic composite a 12-inch thick layer of sandy gravel (top cushion layer) is placed. The surface layer will be a 6 inch thick layer of topsoil. The topsoil will be hydroseeded.

3.1.1 Inspection

The waste pile cover drainage and turf are interrelated and, as such, both should be inspected at the same time. To detect erosion during the period when turf is being established, inspections should be frequent. Inspections should take place 5 days after mowing, monthly for the first wet season year, then every six months.

Unscheduled inspections of the waste pile cover will be made after periods of heavy precipitation, i.e., high intensity short duration storms or sustained periods (days) of above average precipitation. These inspections will be at the discretion of the inspection staff but will occur at a minimum for each (a) short-duration event exceeding two inches of precipitation in a single 24-hour period and (b) sustained-duration event exceeding five inches of precipitation over a seven-day period. The short-duration event is approximately a 2-year return period event and the sustained-duration event is 50% of approximately a 100-year return period (interpreted for the Tacoma Historical Coal Gasification Site (THCGS) from "Storm Water Management Manual for Puget Sound Basin" (Ecology 1990 Draft).

3.1.1.1 Waste Pile Surface Inspection

The waste pile cover will be inspected by persons systematically walking the waste pile surface but paying particular attention to the side slopes where because of the steepness, 3H:1V, problems are more likely to develop. Walking of the waste pile should be in a systematic manner, i.e. in a regular pattern so that the whole surface is observed and changes to features can be noted on a consistent basis. While walking the waste pile surface all cracks and depressions will be noted on a map and photographed. Comparison with the photos taken on previous inspections will permit accurate evaluation of crack or depression activity. For the best viewing of the waste pile cover, inspections should be scheduled for no more than 5 days after mowing. The flows in all culverts and plastic pipes will be noted for comparison with flows found on future inspections.

Topsoil Cracks

All cracks should be dug out to verify that the full crack depth has been observed. Depth of cracks in the 6-inch-thick topsoil layer and the 12-inch-thick top cushion layer will be determined by hand digging to the underlying geonet. The geonet will be inspected for tears and, if torn, the underlying HDPE, geosynthetic clay liner, and/or the geotextile will also be inspected in turn for damage. Surface cracks which lengthen or reappear after filling may require a more thorough investigation fitting the particular failure. The lateral extent of cracks should be flagged so that crack extension can be easily monitored.

Depressions

Depressions in the topsoil should not be disturbed if they do not create a problem such as interfering with the surface drainage, ponding water, or increasing in size between inspections. Problem depressions will be explored by hand digging to the top of the geonet in enough places to establish the cause of the depression, i.e. settlement of the waste pile itself or consolidation and/or downslope movement of the topsoil layer. The condition of the geonet should be evaluated and if excessively stretched or torn the underlying HDPE and clay liner should also be examined. A depression not explained by distress in the cover layer may indicate settlement of the waste pile requiring long-term corrective actions. Seeps, boils or saturated areas will be investigated promptly since their appearance may indicate damage to or malfunction of the drainage layer (geosynthetic composite).

3.1.1.2 Turf Development

Bare Areas

The waste pile cover will be inspected to determine whether the sodded surface necessary to prevent erosion of the 6-inch-thick topsoil surface layer has fully developed. Bare areas and areas of "spotty" growth will be mapped and photographed.

Surface Drainage

Surface drainage of the waste pile was designed to be by sheet flow from the top of the waste pile, down the 3H:1V side slopes to the toe drainage ditches or structures. Settlement of the waste piles may result in concentrated flow paths which may become eroded during periods of heavy precipitation. Erosion may be particularly troublesome in the first one or two years after seeding before the turf is well established and settlement from the final stages of waste pile construction is still occurring. An inspection of the waste pile surface, ditches, precast concrete trenches, culverts and HDPE pipes should be made during and after periods of heavy precipitation. Heavy precipitation events are defined in paragraph 3.1.1 Inspection. Areas of erosion and gullying caused by concentrated water flows will be mapped and photographed and corrective measures designed.

Mowing

Inspection of vegetation mowing should be made within 5 days of the mowing. Inspection should consist of measuring the vegetation height after mowing and reviewing the condition of the cover surface to insure that the mowing equipment is not tearing, or rutting or otherwise damaging the vegetation.

3.1.2 Maintenance

Inspection Reports shall be evaluated by authorized representatives of WNGC.

3.1.2.1 Mowing

Mowing Procedures

A priority goal of the mowing program for the cap area is to minimize the number of mowings. This will reduce potential for soil slippage and cap damage caused by mowing equipment. The actual number of mowings shall be determined by the growth rate of the grass. Mowing of the vegetative cover will be done when the cover is between 12 to 18 inches high. The cover will be mowed to 6 inches high. Such a regime is estimated to involve approximately two to three mowings per year. Mowing will be across the slope so as to minimize the formation of erosional flow paths that may be initiated by up and down slope mowing. Grass clippings will be left to remain and decompose on the turf. Except for the above specifications, the Washington State Department of Transportation (WSDOT) standard specification for mowing [8-01.3(11)] shall be followed (see Appendix C). The mowing equipment operator will be instructed to watch for and report to the WNGC representative any cracks, depressions or other signs of cover damage. All horticultural operations should be done perpendicular to the slope.

Mowing Equipment

The type of mowing equipment will be selected by the mowing contractor but the WNGC Representative will be the sole judge of the adequacy of the equipment and methods of use. Equipment which pulls or rips the vegetation or ruts the turf in any manner will not be permitted. Removal of cuttings will not be required.

Mowing Schedule

The mowing schedule will be the WNGC Representative's responsibility. Since the rate of vegetation growth is seasonal with high growth rates in spring and early summer and low rates in winter, scheduling mowings on a regular basis may not be appropriate. Mowing of the 3H:1V slopes should not be done from December through February or after periods of sustained heavy precipitation. The schedule of mowing and waste pile cover inspection should be coordinated so that the cover inspection occurs not more that 5 days after mowing.

3.1.2.2 Turf Maintenance

Bare Areas

Areas which do not develop a satisfactory turf will be "shallow" disced (2 to 3 inches depth) and resown with the original seed, fertilizer and mulch mixture. Reseeding will be done between March 1 and May 15 or between August 15 and October 1 or when directed by the WNGC Representative. If the resowing does not "take," samples of topsoil from the bare area may be taken and tested as necessary to determine reason for non-germination.

Fertilization and Liming

Topsoil shall be tested annually in the summer for fertility and pH. Annual fertilizer and lime applications shall be based on the results of soil fertility and pH analyses conducted by a qualified soil analysis laboratory. Fertilizer and lime applications shall be applied annually between August 15 and November 15 using broadcast application.

Insect, Disease, Weed, and Tree/Shrub Control

No pesticides, including herbicides, shall be used at any time. Control of noxious weeds shall be by mechanical or physical means. Invasions of trees and shrubs [such as Scot's broom (Cytisus scoparius)] shall be controlled using hand-pulling and mowing.

3.1.2.3 Cracks in Topsoil

Cracks Which Do Not Damage the Geosynthetic Composite

If inspection of a crack shows that the crack does not affect the multi layer geosynthetic composite, the crack shall be backfilled with the same material used in the original construction and compacted in lifts, 4 inches in compacted thickness. Compaction will be by 2 passes of a manually operated compactor or as directed by the WNGC Representative. The topsoil shall be seeded, fertilized and mulched by hand spreading methods.

Cracks Which Damage the Geosynthetic Composite

If inspection of a crack shows that the multilayer geosynthetic has been torn or stretched, the existing topsoil will be removed to expose the affected area. The damaged area shall be repaired by methods recommended by the material manufacturers. The WNGC Representative may request that a field representative of the material manufacturer and/or the original installer be present when the initial repairs are being made. The excavation shall be backfilled with the same material used in the original construction. The material shall be placed in lifts 4 inches in compacted thickness. Compaction shall be by 2 passes of a manually operated compactor or as directed by the WNGC Representative. The topsoil shall be seeded fertilized and mulched by hand spreading methods.

3.1.2.4 Depressions in Turf

Shallow Depressions

Depressions which do not affect either the surface drainage or the multilayer geosynthetic composite will not be disturbed.

Deep Depressions

Depressions causing ponding or otherwise affecting surface drainage of the waste pile surface but not affecting the multilayer geosynthetic will be regraded with topsoil to the original design grades or as directed by the WNGC Representative. The topsoil will be compacted by 2 passes of a manually operated compactor and seeded, fertilized and mulched as specified for the original construction.

Depressions which, upon inspection are found to have resulted in damage to the multilayer geosynthetic shall have all topsoil removed, the geosynthetic repaired and the topsoil replaced and vegetated as described above for "Cracks Which Damage the Geosynthetic Composite."

3.1.2.5 Surface Drainage

Surface Drainage During Heavy Rain

Temporary maintenance of surface drainage over erosion-damaged areas during heavy rains shall consist of covering the particular erosion area with plastic sheeting and the construction of sandbag headwalls to direct the flow onto the plastic sheeting. Sandbag headwalls with culvert pipe laid on the slope may be required for larger concentrated flows. During heavy rains eroded material carried into ditches should be removed to maintain ditch flows and to prevent flows from "jumping" the ditch causing additional slope erosion.

Surface Drainage After Heavy Rains

The permanent repair for each area of slope erosion repair will be unique and will require an "individual" design. In general the restoration of surface drainage will be accomplished by regrading with topsoil to original grades or, if possible, grades established to accommodate additional settlement. Regraded areas will be reseeded as specified for original construction.

3.2 DRAINAGE DITCHES AND CULVERTS

The WNGC drainage system including drainage ditches, culverts, Detention Basin No. 1, the outfall to the BNRR Ditch, and the BNRR Ditch shall be inspected twice in the first year after completion of the waste pile cover, with the second inspection conducted after the first fall-winter period of heavy precipitation. Inspections shall be performed annually after the first year. Waste pile cover drainage will be inspected at the same time as the waste pile turf is inspected, as discussed in Section 3.1.

3.2.1 Inspection

Inspection of storm drainage systems is detailed in Section 8.

3.2.2 Evaluation

Inspection Reports shall be evaluated by authorized representatives of WNGC.

The designed function of the drainage system is to collect and drain stormwater from the site, thus preventing the water from seeping, leaking, or infiltrating to the groundwater. This function is complemented by the operation of the detention basins that collect the stormwater and slowly release it to the downstream systems without causing flooding or erosion. Conditions that impair the system's function require correction action. Other causes of impairment are:

1. Settlement or misalignment of drainage structures,
2. Structural cracks or holes,
3. Safety hazards that prevent maintenance,
4. Vegetation growth in open ditches.

Drainage performance shall be evaluated by visual inspection of the installed drainage elements. The drainage elements include catch basins, storm sewer pipes, open drainage ditches, detention basins, and flow control structures. Drainage surfaces shall be evaluated for conditions which prevent or impede drainage. Generally, the drainage system should be in good working order. Evidence of erosion, trash, accumulated sediment, or flooding usually indicates an improperly functioning system that requires corrective actions or maintenance.

3.2.3 Maintenance

Maintenance of storm drain systems is covered in Section 9.

3.3 DETENTION BASIN NO. 1 ASPHALT

3.3.1 Inspection

Inspections in the Detention Basin No. 1 area will be performed on an annual basis. Hydraulic conductivity testing of asphalt pavements shall be performed at 5-year intervals. A detailed description of the asphalt inspection method is provided in Section 6.

3.3.2 Evaluation

Inspection Reports shall be evaluated by authorized representatives of WNGC. The settlement of pavement will be evaluated principally by visual observations and the comparison of photos and videotape of the as-built condition and records of previous inspection.

The principal design criterion of the asphalt pavement is that it have a permeability of 1×10^{-7} cm/sec. or less as determined in the laboratory by ASTM D 5084 test procedures. Pavement permeability will be assessed by taking one core per acre and testing it in the laboratory by ASTM D 5084. Test results indicating permeabilities higher than 1×10^{-7} cm/sec shall be deemed unacceptable. At the discretion of WNGC, additional testing may be performed to bound the problem area or identify the occasional defective test. All asphaltic concrete pavement potentially represented by unacceptable tests shall be remediated and then retested. A copy of ASTM D 5084 is provided in Appendix C.

3.3.3 Maintenance

Maintenance procedures for asphalt pavement are provided in Section 7.

3.4 SECURITY FEATURES

The perimeter fence shall be inspected at the same time as the waste pile surface for damage, deterioration or clogging with vegetation. Any condition discovered which would impair the effectiveness of the barrier shall be repaired as required to restore the effectiveness of the barrier.

4.0 JS&S OPERATING AREA

4.1 OPERATING AREA CONCRETE PAVING

4.1.1 Inspection

Inspection of the JS&S pavements should be scheduled twice during the initial year of use. The lack of elevation change across the JS&S portion of the site may make it difficult to maintain surface drainage should settlement occur. Foundation consolidation settlement, particularly in areas where stockpiling of materials occurs, might result in settlement, the formation of depressions and the "cracking" of the pavement surface. Inspection of the JS&S area shall pay particular attention to the surface drainage and the formation of depressions. Inspection for these types of pavement distresses is facilitated if the inspection is made during or immediately after a rain storm. Note that because of the stockpiled material on the paved area only about 50 percent of the area is anticipated to be available for inspection. The exposed portion shall be taken to be representative of the whole. After the initial year pavement inspections should be on an annual basis. A detailed description of the method of inspection of concrete paving is given in Section 10.

4.1.2 Evaluation

Inspection Reports shall be evaluated by authorized representatives of WNGC. The settlement of pavement will be evaluated principally by visual observations and the comparison of photos and videotape of the as-built condition and records of previous inspection.

4.1.3 Maintenance

Maintenance procedures for concrete paving are given in Section 11.

4.2 OPERATING AREA ASPHALT PAVING

4.2.1 Inspection

Inspection of the JS&S pavements should be scheduled twice during the initial year of use. The lack of elevation change across the JS&S portion of the site may make it difficult to

maintain surface drainage should settlement occur. Foundation consolidation settlement, particularly in areas where stockpiling of materials occurs, might result in settlement, the formation of depressions and the "alligatoring" of the pavement surface. Inspection of the JS&S area shall pay particular attention to the surface drainage and the formation of depressions. Inspection for these types of pavement distress is facilitated if the inspection is made during or immediately after a rain storm. Note that because of the stockpiled material on the paved area only about 50 percent of the area is anticipated to be available for inspection. The exposed portion shall be taken to be representative of the whole. After the initial year pavement inspections should be on an annual basis. A detailed description of the method of inspection of asphalt paving is given in Section 6.

Wear and tear and settlement damage affecting the pavement accumulates gradually and its progress is normally tracked in scheduled inspections.

Penetration or gouging damage from operational incidents, such as dropping of sharp and/or heavy objects onto the pavement, is potentially immediately damaging to the performance of the THCGS remedy and requires immediate inspection to determine repair requirements. The Party conducting the operation which led to the damage shall be responsible for arranging for or providing an inspection and repair promptly following the occurrence of any damage which appears to penetrate through or crack the pavement. Pavement hydraulic conductivity testing of asphalt pavements shall be performed at 5-year intervals.

4.2.2 Evaluation

Inspection Reports shall be evaluated by authorized representatives of WNGC. The settlement of pavement will be evaluated principally by visual observations and the comparison of photos and videotape of the as-built condition and records of previous inspection.

Initially the subgrade performance shall be evaluated by visual observation of the overlying pavements. Should excessive pavement distress occur as evidenced by severe or reoccurring pavement cracking and/or subsidence over an area, removal of the pavement and the underlying top and base courses maybe necessary to determine what corrective actions are necessary to stabilize the subgrade materials. Test results indicating permeabilities higher than 1×10^{-6} cm/sec shall be deemed unacceptable. At the discretion of WNGC, additional testing may be performed to bound the problem are or identify the occasional defective test.

All asphaltic concrete pavement potentially represented by unacceptable tests shall be remediated and then retested.

4.2.3 Maintenance

Procedures for maintenance of asphalt paving are given in Section 7.

4.3 DRAINAGE SYSTEM

The JS&S drainage system includes catch basins, piping, Detention Basin No. 2, and the outfall to the BNRR Ditch. The drainage system shall be inspected twice in the first year of use, with the second inspection conducted after the first fall-winter period of heavy precipitation. Portions of the drainage system that are covered by material stockpiles at the time of the initial inspection shall be uncovered for viewing on the next inspection. Inspections shall be performed annually after the first year.

4.3.1 Inspection

Inspection of storm drainage systems is detailed in Section 8.

4.3.2 Evaluation

Inspection Reports shall be evaluated by authorized representatives of WNGC.

Drainage performance shall be evaluated by visual inspection of the installed drainage elements. The drainage elements include catch basins, storm sewer pipes, open drainage ditches, detention basins, and flow control structures. Drainage surfaces shall be evaluated for conditions which prevent or impede drainage. Generally, the drainage system should be in good working order. Evidence of erosion, trash, accumulated sediment, or flooding usually indicates an improperly functioning system that requires corrective actions or maintenance.

The design function of the drainage system is to collect and drain stormwater from the site, thus preventing the water from seeping, leaking, or infiltrating to the groundwater. This function is complemented by the operation of the detention basins that collect the stormwater and slowly release it to the downstream systems without causing flooding or erosion.

Conditions that impair the system's function require correction action. Other causes of impairment are:

1. Settlement or misalignment of drainage structures,
2. Structural cracks or holes,
3. Safety hazards that prevent maintenance,
4. Excessive growth of vegetation.

4.3.3 Maintenance

Maintenance of storm drainage systems is detailed in Section 9.

4.4 DETENTION BASIN NO. 2 ASPHALT

4.4.1 Inspection

Pavement hydraulic conductivity testing of asphalt pavements shall be performed at 5-year intervals. A detailed description of the asphalt inspection method is provided in Section 6. Inspection of the JS&S pavements should be scheduled twice during the initial year of use. Inspection for these types of pavement distresses is facilitated if the inspection is made during or immediately after a rain storm.

The principal design criterion of the asphalt pavement is that it have a permeability of 1×10^{-7} cm/sec. or less as determined in the laboratory by ASTM D 5084 test procedures. Pavement permeability will be assessed by taking one core per acre and testing it in the laboratory by ASTM D 5084. Test results indicating permeabilities higher than 1×10^{-7} cm/sec shall be deemed unacceptable and all asphaltic concrete pavement potentially represented by this test shall be remediated and then retested. A copy of ASTM D 5084 is provided in Appendix C. Pavement hydraulic conductivity testing of asphalt pavements shall be performed at 5-year intervals. A detailed description of the asphalt inspection method is provided in Section 6.

4.4.2 Evaluation

Inspection Reports shall be evaluated by authorized representatives of WNGC.

4.4.3 Maintenance

Maintenance of asphalt paving is detailed in Section 7.

5.0 RECORDS

5.1 DOCUMENTED RECORD OF INSPECTION & MAINTENANCE

All inspections and maintenance work performed under this program shall be documented. Documents shall be prepared in accordance with the format required by the procedure governing the activity.

5.2 PUBLICATION OF SUMMARY REPORTS

WNGC shall publish a summary report of inspection and maintenance activities on THCGS annually, including a summary of activities performed by each of the Parties, based on documents received. Copies of the summary report shall be furnished to the Parties, the Environmental Protection Agency, and the Washington Department of Ecology.

5.3 RECORDS MAINTENANCE

The records of all inspection and maintenance activities conducted by all the Parties on THCGS shall be kept and maintained by WNGC. Records shall be available for review by an authorized representative of any of the Parties or the Environmental Protection Agency and the Washington Department of Ecology. WNGC and its contractors shall preserve all documents, records, and any information relating to the performance of the work for a period of 10 years after EPA's Certification of Completion. WNGC will notify an authorized representative of the United States 90 days prior to destruction of any records or documents relating to this project.

6.0 INSPECTION OF ASPHALT SURFACES

6.1 ASPHALT SURFACE CONDITIONS.

The surface condition of the asphalt will be visually inspected to observe and record notes on the type and extent of surface defects. Inspection report forms to document the inspection are provided in Appendix A. In addition to these forms, photographs and sketches to record inspected areas and locations of damage shall be used as necessary.

There are several types of pavement defects that may be found during inspection. Some defects will affect the performance of the pavement more than others. To identify the different types of defects a description is provided below.

6.2 TYPES OF ASPHALT SURFACE DEFECTS

Identification of the types of defects will be useful to interpret the cause of the condition as well as the necessary corrective action or repair methods.

6.2.1 Cracks

There are several types of cracks which may appear in an asphalt pavement. The types of cracks and their causes are described below.

A. Alligator Cracks

Alligator Cracks are interconnected cracks forming a series of small block resembling an alligator's skin or chicken wire. They are usually associated with a granular untreated base that has failed or with a resilient (spongy) subgrade.

B. Edge Cracks

Edge Cracks occur parallel to the edge of the pavement about a foot or so away. Cracks branching toward the pavement edge may occur with this type of cracking. Typically edge cracks are caused by lack of support for the pavement, but also may be caused by settlement or tilting of the base material underlying the cracked area.

C. Joint Cracks

Joint cracks would most likely occur between adjoining spreads of pavement. This type of crack is usually caused by a weak seam or poor bond between these adjoining spreads of pavement.

D. Settlement Cracks

Settlement cracks would most likely occur where differential settlement is expected, such as around the building footings or around storm drainage structures.

E. Other Cracks

Defects in asphalt pavements can also be caused by temperature changes, frost and freeze thaw cycles, moisture changes, reflection cracking of overlays, weathering, earthquakes and operation related cracks. Predicting the configuration of the asphalt pavement distress due to these defects is difficult and pavement repairs should be designed for the particular type of failure that has occurred.

6.2.2 Settlement

Settlement of the asphalt surface may occur as the foundation consolidates. Localized depressions in the surface are caused by settlement. The depressions may or may not be accompanied by cracking. Areas of settlement can easily be detected by visual inspection, especially during a rain.

6.2.3 Rutting

Asphalt pavement can rut when the subgrade fails under a single heavy load or repetitive loads of smaller magnitude. A rutting failure is more likely to occur when the subgrade is saturated, or thawing in conjunction with a saturated subgrade. The pavement ruts results in a "tearing" of the asphalt particularly along the sides of the rut. Water fills the ruts during precipitation and seeps through the tears into the subgrade further weakening the subgrade and a progressive failure of the pavement occurs.

6.2.4 Slips

Slips are movements of the pavement during warm weather. Slips usually are crescent-shaped cracks and have an appearance that resembles a "flowing" movement. Slips most likely will occur on inclined pavement surfaces. Slips are caused by a lack of bonding between the surface layer and course beneath.

6.2.5 Abrasion and Erosion

Abrasion and erosion is the progressive loss of surface material by weathering and traffic abrasion. The progressive loss of aggregate from the surface can be seen visually and is evidenced by loose pieces of aggregate on the asphalt pavement surface.

6.2.6 Potholes

Potholes are bowl shaped holes of various size, in both depth and width, caused by localized disintegration of the asphalt pavement. They are usually caused by weakness in the pavement resulting from a weak subgrade or base course.

6.2.7 Cleaning Surfaces to be Inspected

To the extent practical, pavements will be cleaned of all dirt or material that would interfere with a visual observation of the pavement surface. In come cases, pavements will have to be cleaned of dirt or other material that cannot be removed by a broom. However, the method of cleaning must not increase the permeability of the pavement—e.g., power washing and power brooms are not recommended because of the potential damage to the surface which may affect the properties of the surface. Any surface depressions deeper than 1/2 inch shall have any standing water removed and the surface cleaned of muddy material to allow inspection. When requested by the inspection staff, piles of material shall be moved to permit observation of the pavement. Inspection shall consist of systematically walking the area to observe and record any distress features.

6.2.8 Operational Related Damage

Particular attention will be paid to pavement damage in:

1. Areas where heavy pieces of metal may have been dropped resulting in holes being punched in the asphalt pavement.

2. Areas where heavily loaded metal containers have been placed directly on the pavement resulting in a creep type displacement of the pavement. This can be a particular problem if the container is in direct sun in hot weather.

3. Areas where track-type equipment has been used resulting in a "scouring" of the pavement surface.

4. Stockpile areas.

6.3 TESTING ASPHALT SURFACES

The asphalt pavement shall be tested to determine if the permeability of the pavement is changing with time. Permeability testing shall be in accordance with ASTM D 5084. The relationship of changing permeability with time can be established by comparing ASTM D5084 test results over time to determine whether a change in permeability is occurring. Appendix C contains a copy of ASTM D 5084.

7.0 MAINTENANCE OF ASPHALT SURFACES

Maintenance procedures for correcting distresses or defects in asphalt pavements include patching, crack and surface sealing, and in some cases resurfacing. Patching may be either a temporary or permanent repair. Crack sealing is accomplished using emulsified or cutback asphalts, special asphalt compounds, specialty crack and joint sealers or possibly sealing the entire surface area. Surface treatments with or without aggregate, and thin overlays can also be part of the maintenance procedure.

Temporary repairs of cracks will usually suffice for a few months. Temporary repairs shall be made when the materials to make a permanent repair are not available (i.e., hot mix asphaltic concrete is generally not available in winter months); when not making a temporary repair could result in excessive damage to additional areas of pavement or when weather conditions (i.e., cold or wet) are such that an effective permanent repair can not be made.

The purpose of the asphalt pavement maintenance program is to preserve the structural and permeability integrity of the asphalt pavement. The maintenance program will continue to provide a surface for driving, as well as the collection of surface water drainage. The asphalt pavements are required to be constructed with a permeability less than 1×10^{-7} cm/sec. This permeability is to be maintained throughout the life of the project by implementation of the maintenance program.

7.1 PATCHING

Patching is probably the most common method of repair. Patches can be used to repair defects varying from cracked areas and shallow abrasions to deep holes. Patches can be either deep patches or "skin" patches depending on the severity of the defect.

7.1.1 Deep Patches

Deep Patches at least the same depth as original pavement are used for making permanent repairs to the pavement. The material should be removed to the depth necessary to reach firm support. The excavation should extend at least 12 inches into the good pavement surrounding the area to be patched (Figure 1). Holes should be square-edged and cut rectangular using a pavement saw.

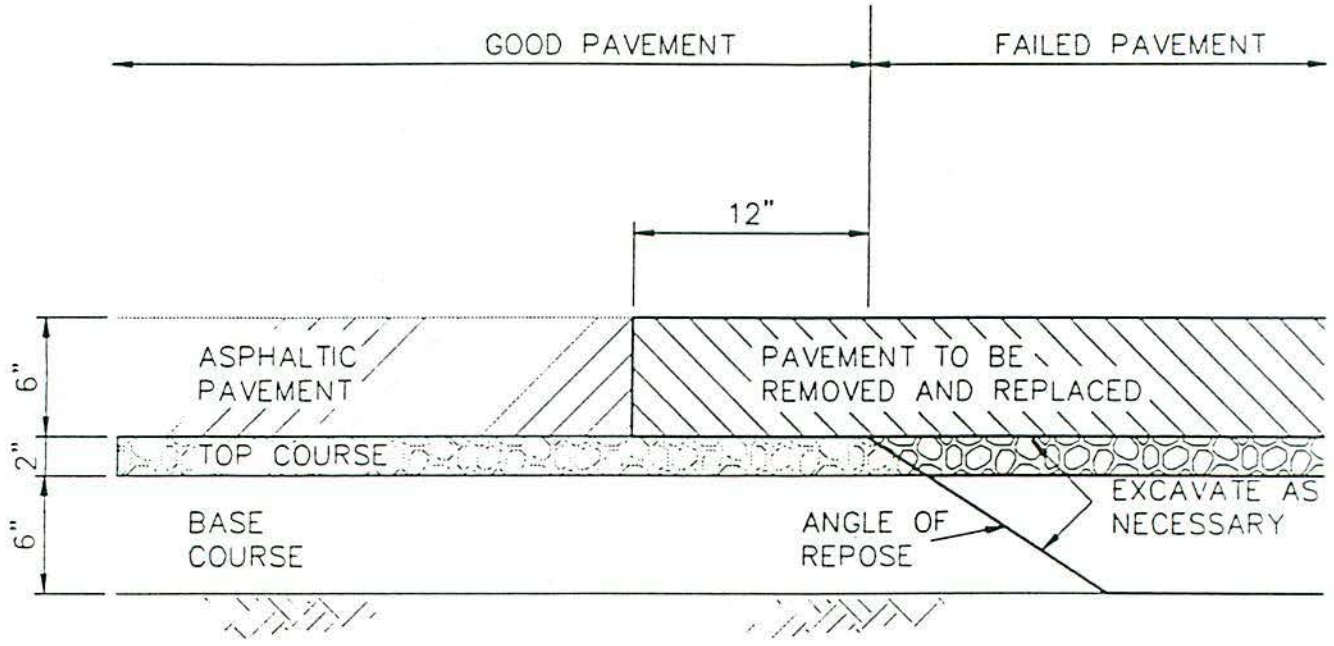


FIGURE 1
Pavement Sawcut Detail

The hole should be backfilled with a dense-graded hot-asphalt plant mix. Tack coating must be applied to the vertical sides of the hole, and the granular base should be primed before the asphalt mix is placed. The repair is completed by placing the hot-mix asphalt and compacting it flush with the surrounding surface. Compaction can be achieved using a vibratory-plate compactor or a steel wheeled roller. Pavement reconstruction that exceeds 1,000 ft^2 in area should also be tested for permeability by at least one core sample tested by ASTM Method D 5084 and evaluated against the 1 x 10^{-7} cm/sec permeability criterion.

7.1.2 Surface Patches

Surface or "skin" patches may be either a temporary or permanent repair. Surface patches do not normally require removal of existing pavement. A precoated fabric such as "Petrotac" (see Appendix B) is one type of surface patch. Surface preparation for this type of patch should be in accordance with the manufacturer's recommendations.

Another type of surface patch is a layer of hot-mix asphalt that covers the depressed area. A sand asphalt mixture is used for the patch so the layer can be "feather-edged" to a zero thickness and the maximum thickness does not exceed 3/4 inches. Before the area is patched, the area should be cleaned with high-pressure air and a tack coat should be applied over the entire area. The hot-mix is then spread over the tack coat and compacted with a roller or flat-plate vibratory compactor.

7.2 SURFACE TREATMENTS

Surface treatments consist of filling cracks with an asphalt sealer or applying a seal coat to reduce the permeability of the asphalt surface.

7.2.1 Crack Sealants

Crack sealing is done with specially prepared crack and joint sealers. Suitable types of crack sealant are #9000-S and #9000-SH fillers manufactured by the Koch Materials Company, Oklahoma City, Oklahoma (see Appendix B) or equal. Surface preparation should be in accordance with manufacturers recommendations, but usually consist of thorough cleaning with high-pressure air.

It is usually not practical to individually seal cracks that are less than 1/4 inch wide. For small, hairline cracks an asphalt slurry mixture can be squeegeed over the surface and forced into the cracks.

7.2.2 Seal Coats

Seal coats or surface sealers are widely available and marketed under many trade names. Some are emulsified asphalts, some contain rubber latex, and most have fillers such as ground rubber, mineral aggregates, or fibers. Seal coat shall be applied every 5 years. In local areas additional seal coats shall be applied any time the pavement permeability does not meet the design criteria of 1×10^{-7} cm/sec.

7.3 CRACK REPAIRS

Repairs to cracks such as alligator, edge, joint, or settlement cracks can be made by patching or sealing as described in the previous sections.

7.4 DEPRESSION REPAIRS

Depressions caused by settlement shall be permanently repaired with hot-mix asphalt, compacted to restore the area to the same grade as the surrounding pavement. The surface shall be thoroughly cleaned and a tack coat applied prior to placing the hot-mix asphalt. The edges of the repaired area shall be ground out to a depth of 1 inch to avoid feathering the overlay.

7.5 SLIP REPAIRS

Slips shall be permanently repaired by constructing a deep patch with hot-mix asphalt.

7.6 ABRASION AND EROSION REPAIRS

Abrasion and erosion defects shall be permanently repaired by constructing either a deep patch or a surface patch.

7.7 POTHOLE REPAIRS

Permanent repairs to potholes shall be made by constructing a deep patch with hot-mix asphalt. Temporary repair usually involves cleaning out the hole and filling it with a premixed asphalt patching material.

8.0 INSPECTION OF STORM DRAINAGE SYSTEMS

The THCGS consists of two distinct drainage systems: the waste pile and the perimeter ditches drain to Detention Basin Number 1; and the Joseph Simon and Sons' area drains to Detention Basin Number 2 (see Figure 2). JS&S will be responsible for maintenance of that portion of the drainage system which lies on JS&S operating areas and also for maintenance of the associated Detention Basin Number 2 and its outfall structures. WNGC will be responsible for the system which drains to Detention Basin Number 1, its outfall structures, and the BNRR Ditch.

8.1 DRAINAGE SYSTEM CONDITION INSPECTIONS

Scheduled inspections of the storm drainage system are necessary to evaluate performance and to identify maintenance needs. Walking the site to visually observe each drainage feature is an effective way of conducting the inspection. Inspection during or immediately after rainfall or heavy precipitation events is probably the best time to make an accurate evaluation. Heavy precipitation events are defined in paragraph 3.1.1 Inspection. Inspection report forms for the various drainage features are provided in Appendix A to facilitate the inspector. Photographs and contract drawings are also useful to document the observed conditions.

Defective conditions identified during inspection of the drainage system can be classified as either structural or non-structural. Structural defects include cracks, settlements, and misalignments. Non-structural defects comprise mostly of the accumulation of trash or sediment and excessive vegetation growth in open ditches, and usually requires routine type maintenance.

Infiltration and exfiltration testing of the drainage system for the JS&S property has been performed during construction of the system in accordance with Section 17-7.3 (4) of the 1994 Washington State Standard Specifications for Road, Bridge, and Municipal Construction. The drainage system for the JS&S property will be visually observed during scheduled inspections during seasonally dry periods of the year. If flow is noted in the absence of recent precipitation or releases of water to the system, appropriate actions will be taken to assess the source of the flow and impact on the environment.

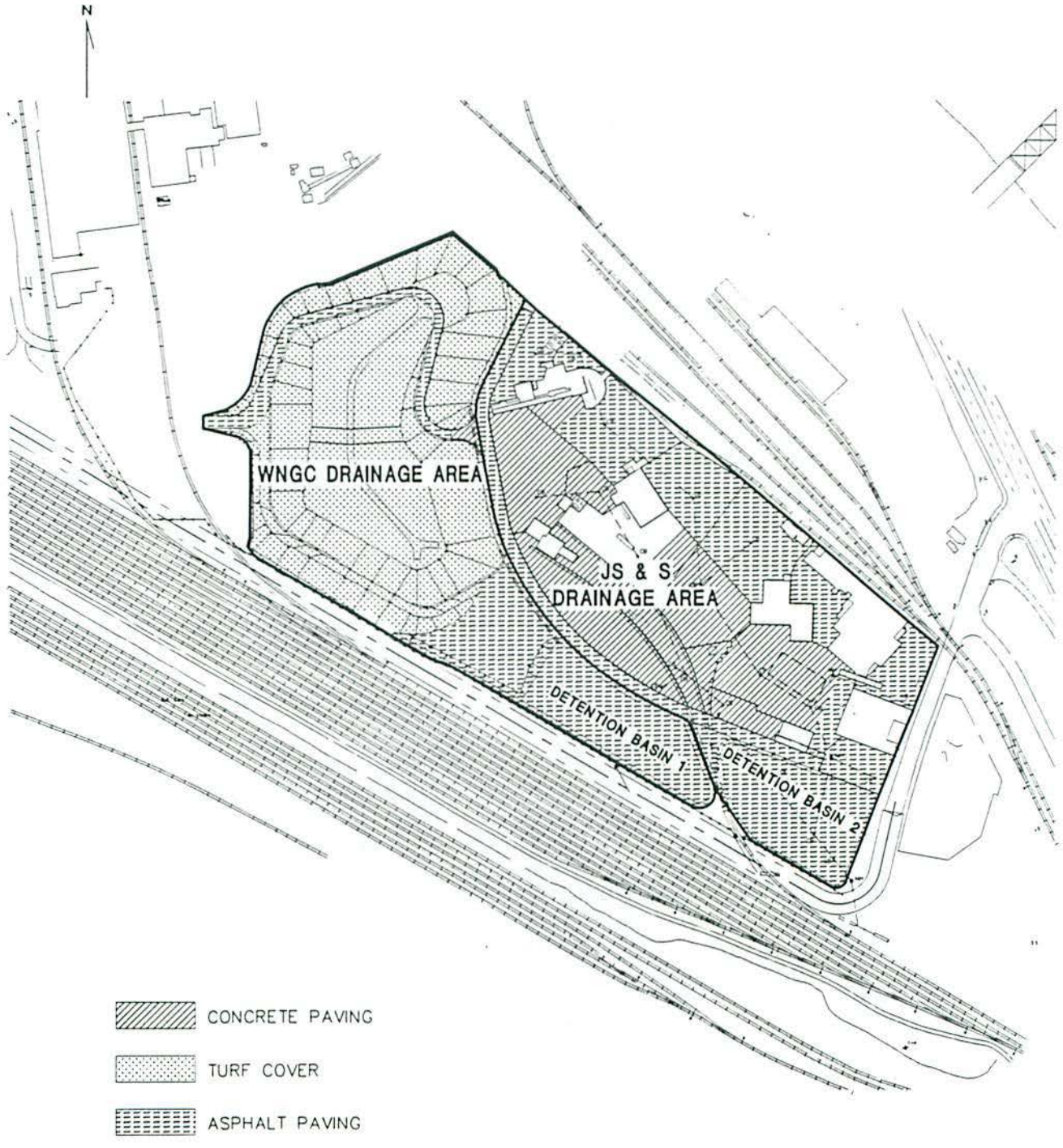


FIGURE 2
THCGS Drainage Areas

8.2 DRAINAGE FEATURES

The drainage features which require inspection include:

A) Detention Basins
B) Control Structures/Flow Restrictors
C) Catch Basins and Manholes
D) Pipes
E) Open Ditches
F) Precast Concrete Trenches

9.0 MAINTENANCE OF STORM DRAINAGE SYSTEMS

Responsibility for the maintenance of the two drainage systems will be divided between the owners of the systems. JS&S will be responsible for maintenance of that portion of the drainage system which lies on JS&S operating areas and the associated Detention Basin Number 2. WNGC will be responsible for the BNRR Ditch, Detention Basin No. 1, and the system which drains into Detention Basin No. 1.

Maintenance which corrects defective conditions of the drainage elements usually involves either cleaning, or making repairs. Occasionally, replacement may be required.

9.1 CLEANING

Cleaning is routine maintenance associated with the removal of trash, debris, vegetation and accumulated sediments from pipes, catch basins, ditches, and detention basins. This type of maintenance should be performed concurrently with inspection. In addition, liquid wastes such as oil, gasoline, or other contaminants that could be flushed downstream during a rainstorm shall be cleaned up. All wastes shall be disposed offsite in a proper and legal manner.

9.2 REPAIRS

Repairs are generally non-routine type maintenance. To correct structural defects, repairs may be required to patch cracks or joints in pipes, catchbasins, or other structures. Each structural defect will have to be evaluated on an individual basis so that repair recommendations can be made. Repairs and replacements shall be made to restore conditions in accordance with the original contract drawings and specifications. Repeated failures of the same type and/or in the same location shall be reviewed to determine the cause of the repeated failure and a revised "fix" for the failures be developed.

10.0 INSPECTION OF CONCRETE PAVEMENT

10.1 CONCRETE PAVEMENT INSPECTION AREAS

JS&S uses concrete paved areas for stockpiling of materials. Having all concrete areas available for visual inspection at any one time will not be practical. Coordination between JS&S and the inspection staff will be required to insure that concrete pavements are available for inspection as scheduled. For inspection purposes the concrete pavements will be divided into areas defined as the catchment areas shown on Figure 3. Prior to scheduling an inspection the parties will agree on which catchment areas are to be inspected and JS&S will conduct its operations so that the agreed upon catchment areas can be visually inspected on the scheduled inspection date. Representative areas will be cleaned of materials stockpiles for inspection.

10.2 PREPARATION OF CONCRETE PAVEMENT SURFACES

All concrete pavement surfaces to be inspected will be cleaned of all dirt that would interfere with a visual observation of the pavement surface ("broom clean"). Areas that do not clean up sufficiently with brooming shall be washed with water at low pressure accompanied by brooming or scraping to remove resistant deposits. High pressure water jetting shall not be permitted as the high pressure jets will blow out the joint sealants. Surface depressions shall have all standing water removed and the surface cleaned of muddy material to allow inspection.

10.3 METHOD OF INSPECTION

Inspections will consist of systematically walking the area to observe and record any distress features. Walking of the waste pile should be in a systematic manner, i.e., in a regular pattern so that the whole surface is observed and changes to features can be noted on a consistent basis. The general locations of damage shall be recorded on attached Figure 3. A detailed sketch, scaled 1 inch equals 10 feet, shall be made of the area along with recommendations for repair. Any concrete pavement noted to be cracked, to have a deteriorated surface or other damage shall be photographed. The location from which these initial photographs were taken shall be recorded so that subsequent photos can be taken from the same location.

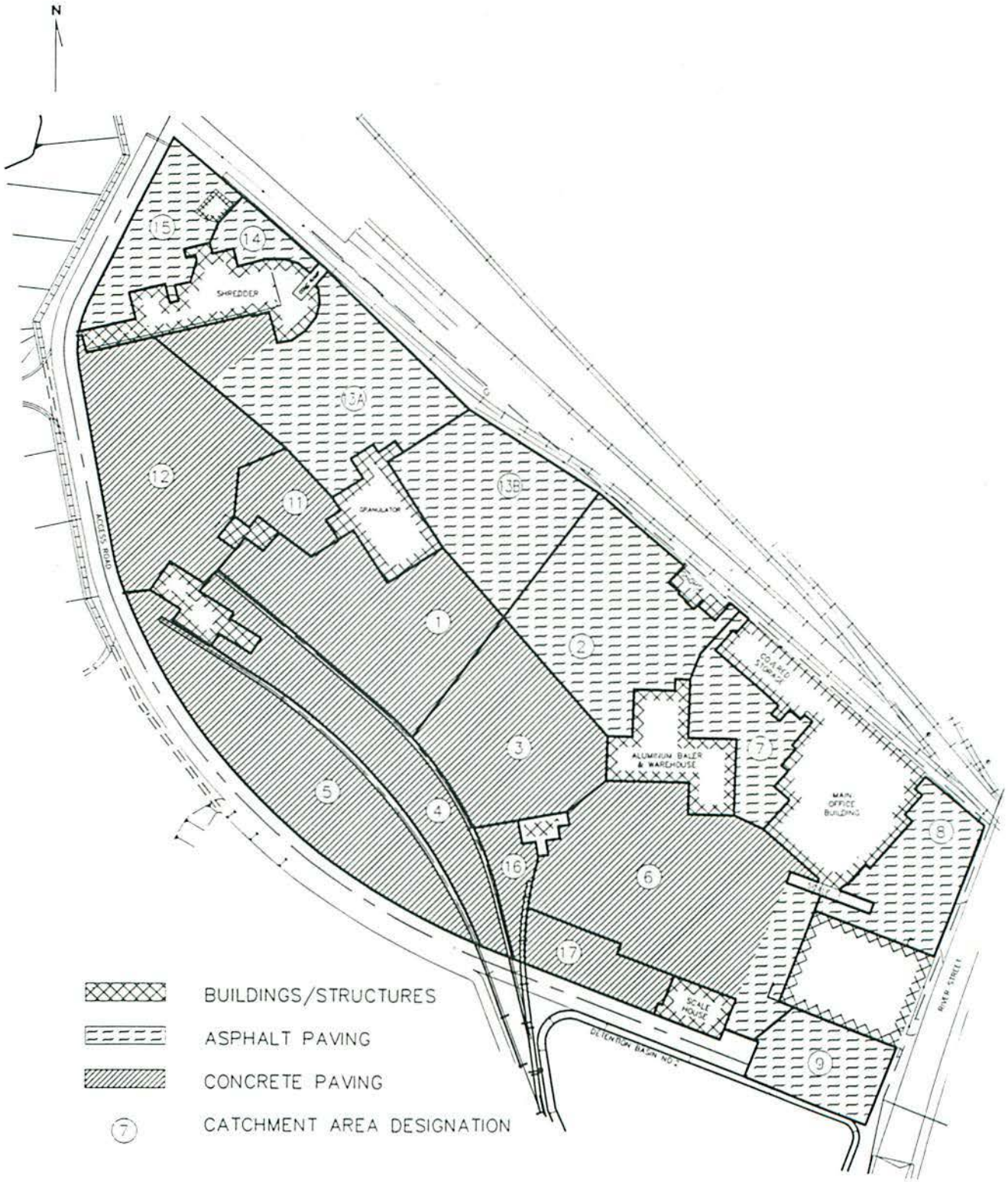


FIGURE 3
JS&S Area Drainage Plan

10.4 CONCRETE SURFACE DEFECTS

10.4.1 Cracks

Cracking of concrete pavements results from the application of stresses exceeding the strength of the concrete. Some of the more probable causes of cracks are discussed below. Over stressing and crack formation in concrete pavements can also result from temperature changes, frost and freeze-thaw cycles, moisture changes and earthquakes.

10.4.1.1 Hairline Cracks

Hairline cracks may result from shrinkage of the concrete as the pavement ages. Hairline cracks are usually "closed" and may be difficult to see. They are normal and are of no concern unless they are wider than 6 mils. Therefore, any crack which cannot be readily seen when the pavement is "broom clean" shall not require documentation.

10.4.1.2 Settlement Cracks

A reduction of pavement subgrade support due to foundation consolidation may result in cracking when the pavement is subjected to relatively large stockpile loads. Cracks from lack of subgrade support will be random in pattern with fresh edges and "open" relative to hairline cracks.

10.4.2 Joint Inspection

10.4.2.1 Concrete to Asphalt Joint

Of particular concern is keeping the joint at the contact between the asphalt and concrete pavements "water tight." Differential settlement across its joint may occur if materials are stockpiled over this joint and may result in separation and/or voids at this contact. This type joint shall be examined carefully and any differential settlement or other signs of joint distress noted for repair.

10.4.2.2 Concrete to Concrete Joint

Concrete to concrete pavement joints have been constructed using dowels and the joint filled with a premolded joint filler. If the joint filler is lost, dirt and water may enter the joint as the concrete slab contracts and the joint opens. Subsequent slab expansion will tend to close the joint which the debris in the joint will not permit, overstressing the concrete along the joint. This overstressing can result in cracking or spalling of the concrete along the joint. Cracking along concrete to concrete joints may also result from overstressing of the dowel system by significant differential loading across the joint.

Concrete to concrete joints should be inspected not only for cracked or spalled concrete, but also for missing joint filler and the limits of these types of failure noted for repair.

10.4.3 Operational Related Damages

10.4.3.1 Abrasion & Erosion

Abrasion of the concrete pavements may result from the operation of vehicles with chains or tracks (bulldozers) or repetitive dragging of storage boxes with metal skids. Water will enter a porous, abraded or inadequately sealed pavement surface resulting in erosion of the surface particularly if accompanied by freeze-thaw conditions. If during visual inspections these type of failures should be observed, the failed areas should be shown on the inspection maps for remedial action.

10.4.3.2 Chipped or Potholed Pavement

The dropping of heavy pieces of metal on the pavement may cause chipping and potholing of the pavement surface. This type damage should be recorded on the inspection maps if the chip penetrates past the plane of reinforcement (2 inches below the surface of concrete).

11.0 MAINTENANCE OF CONCRETE PAVEMENTS

The purpose of the concrete pavement maintenance program is to preserve the structural and permeability integrity of the concrete pavement. This maintenance program will continue to provide a surface for driving, as well as the collection of surface water drainage.

For concrete pavements, the permeability criterion is assumed to be met based on quality design, construction, and maintenance (without permeability testing). Therefore, concrete pavement maintenance should include correcting and repairing any distress, defects, or aging effects in the pavements that indicate the pavement may fail the permeability criterion.

11.1 SURFACE TREATMENTS

Surface treatments will consist of repair of cracks, abraded or eroded areas and chipped or potholed pavements.

11.1.1 Cracks Less Than 6 Mils

Cracks less than 6 mils are normal, are not readily noticeable and do not normally allow passage of water. Accordingly they will not be repaired unless they are associated with a more serious cracking problem. It is not required to measure crack width with an instrument; the judgment of a trained eye will be sufficient.

11.1.2 Cracks Wider Than 6 Mils

Cracks wider than 6 mils will be filled using a material such as Concresive 2070, LVP Acrylic Crack Filler by Master Builders or an equivalent (see Appendix D for concrete repair products). The surface to receive treatment will be cleaned as recommended by the material manufacturer. The material will be applied at the rate and as otherwise specified by the manufacturer.

Cracks wider than 1/8-inch can be filled using acrylic crack filler material such as Renderoc SD2 manufactured by Fosroc Inc., 55 Skyline Drive, Plainview, N.Y. 11803-9966 or an equivalent material. Preparation of the surface for and the application of the material will be as specified by the manufacturer.

11.1.3 Abraded or Eroded Pavements

A sawcut will be required around the perimeter of abraded or eroded pavement areas to be patched. Note that a welded wire fabric (WWF6x6 - W4.0xW4.0) is located 2 inches below the pavement surface limiting the depth of saw cut to not more than 1.5 inches. The pavement area inside the saw cut area will be removed using pneumatic hammers. After all damaged pavement has been removed the chipped area shall be cleaned as recommended by the patching material manufacturer. Patch material shall be Renderoc SD2 as manufactured by Fosroc Inc., 55 Skyline Drive, Plainview, NY, 11803-9966 or an equivalent. Application of the patch material will be as recommended by the manufacturer. The use of "feathered" edged pavement patches will not be permitted.

11.1.4 Chipped or Potholed Pavements

Pavement damage consisting of chipped or pothole gouges which are not deep enough to affect the welded wire fabric located 2 inches below the pavement surface will be sawcut and patched as described above for "abraded or eroded" pavement. Pavement damage which has exposed the welded wire fabric will have the concrete chipped away to completely expose the fabric. Patch material shall be Renderoc SD2 as manufactured by Fosroc Inc., 55 Skyline Drive, Plainview, NY, 11803-9966 or an equivalent. Application of the patch material will be as recommended by the manufacturer.

11.2 JOINT REPAIR

11.2.1 Concrete to Asphalt Joints

Concrete to asphalt pavement joints which have indications that water is flowing into the joint or show openings in the joint shall be sealed using a sealant such as Nitoseal 230 manufactured by Fosroc Inc., 55 Skyline Drive, Plainview, NY, 11803-9966 or an equivalent. Application of the sealant will be as specified by the manufacturer.

11.2.2 Concrete to Concrete Joints

Concrete to concrete joints from which the premolded joint filler has been removed shall be carefully cleaned and new joint filler material installed wherever possible; otherwise the joint may be resealed with the joint sealant specified above for Concrete to Asphalt Joints.

APPENDIX A

INSPECTION AND MAINTENANCE RECORD FORMS

INSPECTION AND MAINTENANCE RECORD
CATCH BASINS AND MANHOLES

CATCH BASIN/MANHOLE NO. _____ DATE: _____

WEATHER CONDITIONS: _____

1a) Is trash, debris, or sediment blocking or clogging the grate openings? ___ YES ___ NO

1b) If yes, describe and estimate volume. _____

_____

1c) Describe maintenance performed and/or required. _____

_____

2a) Is trash, debris, or sediment present inside the basin? ___ YES ___ NO

2b) If yes, describe and measure depth or estimate volume.

_____

2c) Describe maintenance performed and/or required.

_____

3a) Are there any signs of structural damage such as cracks, settlement, or misalignment? ___ YES ___ NO

3b) If yes, describe in detail and provide applicable measurements (attach photos if necessary).

_____

3c) Is grating or cover in place? Any damage? Is grating or cover easily removable to facilitate maintenance? Describe any problems.

_____

3d) Describe maintenance required.

_____

4a) Are there any cracks in the side walls or bottom slab? ___ YES ___ NO
Are there cracks at the joints of the inlet outlet pipe? ___ YES ___ NO

4b) If yes, describe and measure width and length of cracks.

_____

4c) Describe maintenance required.

_____

_____
INSPECTOR'S SIGNATURE DATE

INSPECTION AND MAINTENANCE RECORD
CONTROL STRUCTURE/FLOW RESTRICTOR

LOCATION: _____ DATE: _____

1a) Is trash, debris, or sediment blocking or clogging the inlet pipe? ___ YES ___ NO

1b) If yes, describe and estimate volume. _____

_____

1c) Describe maintenance performed or required. _____

_____

2a) Is trash, debris, or sediment present inside the structure? ___ YES ___ NO

2b) If yes, describe and measure depth or estimate volume. _____

_____

2c) Are there any obstructions such as trash, debris, sediment, or vegetation blocking the orifice or overflow pipe? Describe any problems. ___ YES ___ NO

2d) Is the outlet pipe clear of obstructions? Check by opening the clean-out gate. Does the gate function properly? Describe any problems.

_____

2e) Describe maintenance performed and/or required.

_____

3a) Are there any signs of structural damage such as cracks, settlements, or misalignments. ___ YES ___ NO

3b) If yes, describe in detail and provide applicable measurements (attach photos, if necessary).

_____

3c) Is the cover in place? ___ YES ___ NO

Is the cover easily removable to facilitate maintenance? ___ YES ___ NO

INSPECTION AND MAINTENANCE RECORD
CONTROL STRUCTURE/FLOW RESTRICTOR
Page Two:

Are the ladder rungs in place and secure? ___ YES ___ NO

Describe any problems. _____

_____

3d) Is the flow restrictor pipe assembly securely attached to the structure and outlet pipe? ___ YES ___ NO

Is the assembly in an upright position? ___ YES ___ NO

Are the welded and gasketed joints water tight? ___ YES ___ NO

Are there signs of rust? ___ YES ___ NO

3e) Are there cracks in the walls or slabs of the structure? ___ YES ___ NO

Are there cracks at the joints of the inlet/outlet pipe? ___ YES ___ NO

If yes, describe and measure width and length of cracks. _____

_____

3f) Describe maintenance performed and/or required. _____

_____

_____
INSPECTOR'S SIGNATURE DATE

INSPECTION AND MAINTENANCE RECORD
DETENTION BASINS

DETENTION BASIN NO. _____ DATE: _____

1a) Is there any trash, debris, sediment, or vegetation present in the basin? ___ YES ___ NO

1b) If yes, describe and estimate volume. _____

_____

1c) Describe maintenance performed and/or required.

_____

2a) Is there any evidence of pollutants such as oil, gas, or other contaminants? ___ YES ___ NO

2b) If yes, describe and estimate volume.

_____

2c) Immediate cleanup required. Describe action taken.

_____

3a) Is there any evidence of erosion at the emergency/overflow spillway? ___ YES ___ NO

Is the riprap downstream of the spillway in good condition? ___ YES ___ NO

Are there any rocks missing? ___ YES ___ NO

3b) If yes, describe any problems.

_____

3c) Describe maintenance performed and/or required.

_____

4a) Has any settlement in the basin occurred? ___ YES ___ NO

Are there any cracks in the asphalt? ___ YES ___ NO

4b) If yes, describe and provide measurements.

_____

4c) Describe maintenance required.

_____

_____

INSPECTOR'S SIGNATURE DATE

INSPECTION AND MAINTENANCE RECORD
STORM DRAINAGE PIPES

PIPE LOCATION BETWEEN CB/MH _____ AND CB/MH _____ DATE: _____

Inspection of pipes may require use of a flashlight and mirror to look down the barrel of the pipes. Maintenance may require use of a high pressure spray to flush sediments.

1a) Is trash, debris, or sediment blocking or clogging the pipe? ___ YES ___ NO

1b) If yes, describe extent of blockage. _____

_____

1c) Describe maintenance performed or required.

_____

2a) Is the pipe misaligned or has it settled causing low spots that do not drain freely? ___ YES ___ NO

2b) If yes, describe the nature of problem. _____

_____

_____

INSPECTOR'S SIGNATURE DATE

INSPECTION AND MAINTENANCE RECORD
ASPHALT SURFACES

DATE: _____

WEATHER: _____

LOCATION (circle one):

Simons' Operating Area	Roads	Ditches
Detention Basin 1	Detention Basin 2	
	Other _____	

Check asphalt surfaces for the following defects. Describe the condition and location of occurrence of any observed defect.

		YES	NO
1.	Cracking		
2.	Settlement		
3.	Slips		
4.	Abrasion or Erosion		
5.	Potholes		
6.	Depressions		
7.	Standing Water		

Description of defect (include photos, if necessary):

_____

_____

Maintenance Recommendation: _____

_____

INSPECTOR'S SIGNATURE DATE

INSPECTION AND MAINTENANCE RECORD
CONCRETE PAVEMENT

DATE: _____

LOCATION: _____

1) Date of the last inspection. _____

1a) Is 50% of the concrete asphalt available for visual inspection?
_____ Yes _____ No

1b) Is the exposed area different than that of the previous inspection?
_____ Yes _____ No

1c) Map the locations of the exposed and covered sections of concrete pavement.

2) Are there any signs of structural damage such as cracks, settlements, or misalignments?
_____ Yes _____ No

2a) Map location and describe cracking _____
_____

2b) Size of cracks (mils) _____

2c) Describe the maintenance performed/required. _____
_____

3) Any signs of erosion or abrasion of the concrete pavement? _____ Yes _____ No

3a) If yes, describe in details and map location. _____
_____

3b) Describe the maintenance performed/required. _____
_____

INSPECTION AND MAINTENANCE RECORD
WASTE PILE TURF

DATE:_____

1) What was the date of the last mowing? _____

1a) What is the height of the grass? _____

1b) Any noticeable tearing, rutting or other damage to the vegetation?
_____Yes _____No

2) Any noticeable cracks in the topsoil layer? _____Yes _____No

2a) If yes, describe and provide measurements _____

_____

2b) Is the geonet torn? _____Yes _____No

2c) Is the HDPE punctured or torn? _____Yes _____No

2d) Is the geosynthetic clay liner wet or damaged? _____Yes _____No

3) Any areas of noticeable erosion? _____Yes _____No

3a) Describe maintenance performed and/or required _____

_____

4) Any trees or shrubs growing on the cap? _____Yes _____No

5) Any noticeable signs of burrowing animals? _____Yes _____No
5a) If yes, describe damage and location _____

_____

5b) Describe maintenance required. _____

_____

6) Any areas of excessive settlement? _____Yes _____No

6b) Map location and describe maintenance required. _____

_____

_____
Inspector's Signature Date

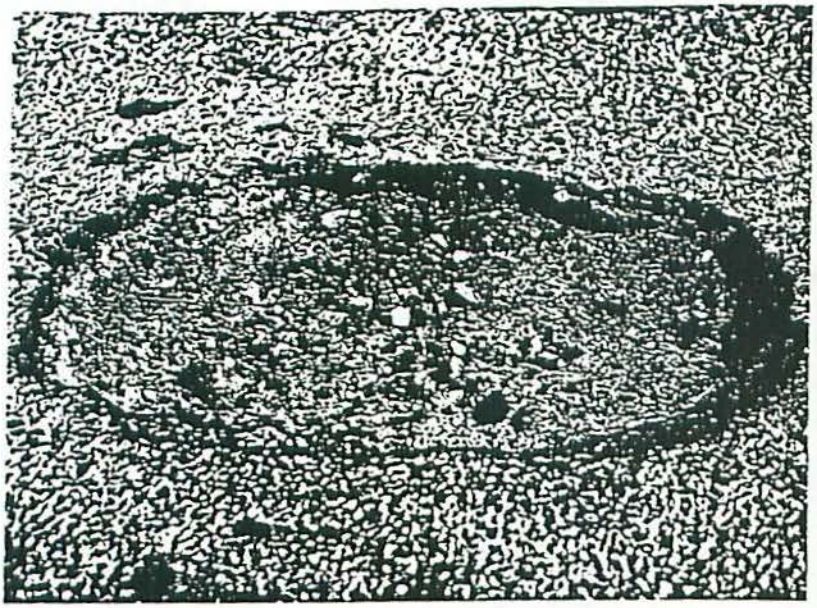
APPENDIX B

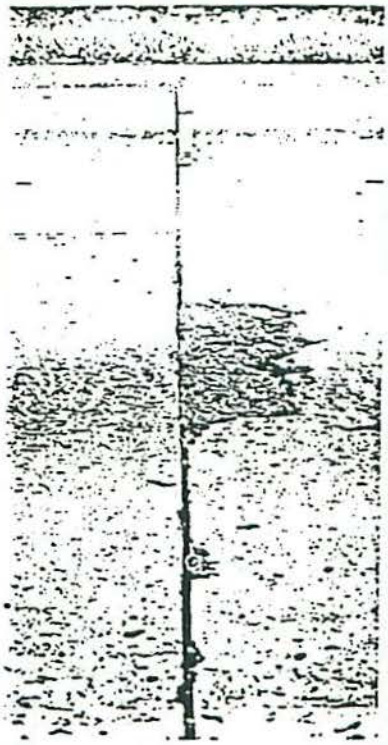
ASPHALT REPAIR PRODUCTS

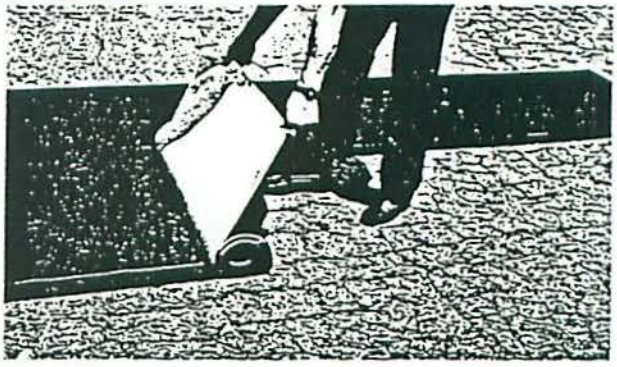
- POTHOLES
- ALLIGATOR CRACKS
- PORTLAND CEMENT JOINTS
- BRIDGE DECKS

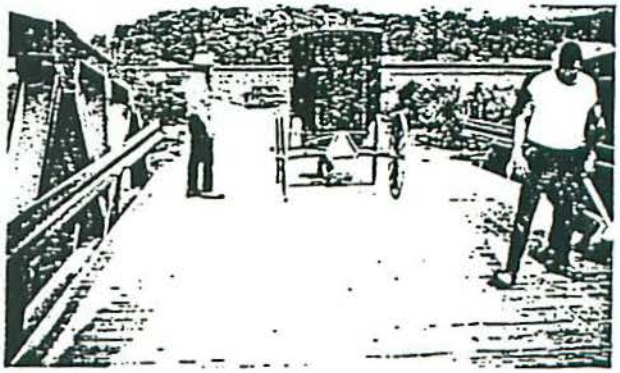
PETROTAC®

A specialty product of the Petromat® System









PETROTAC®

NONWOVEN PHILLIPS 66 FABRIC

PETROTAC *Installation Procedures*

EQUIPMENT

No specialized equipment is required for unrolling and placing Petrotac. Often, use of a rope will assist unrolling. For large jobs, however, simplified "hand-truck" type equipment can be easily designed and constructed.

If application of a primer is specified, brushes, rollers, or spray equipment will be necessary. Otherwise, utility knives and pneumatic rolling equipment are all that are needed.

SURFACE PREPARATION

Pavement: Before installing Petrotac, the pavement surface must be sufficiently dry to prevent moisture migration from within. It should be free of dust, dirt, vegetation and excess crack filling material. Cracks greater than ⅜ inch wide should be filled with a suitable crack filler and excess filler material removed.

Severely spalled or otherwise distressed areas must be repaired in accordance with accepted paving practices. Portland cement concrete pavement slabs should be stable and subsided shoulder joints raised to proper grade.

Primer: No prime coat is needed when dry pavement temperature is 70°F or above. Use of a primer is recommended if pavement temperature is below 70°F, particularly if the Petrotac may be exposed to traffic and moisture prior to overlay.

Any suitable priming material composed of refined asphalt and rapid drying solvent may be used. As soon as it cures it is ready to receive the Petrotac.

A list of suitable priming materials and elastomeric mastics that have been evaluated by Phillips Fibers is available.

TEMPERATURE

Pavement temperature should be 45°F or above when installing Petrotac. Storage temperatures should not exceed 125°F.

REPAIR OF LOCAL DISTRESSED AREAS

Areas of local distress, including alligator-cracked areas and potholes, can be beneficially treated with Petrotac prior to subsequent resurfacing.

Preparation: Local areas of base failure, usually manifested by pavement subsidence and alligator cracking, may in some cases require installation of a leveling course prior to Petrotac treatment. This is an engineering judgment to be made by the responsible engineer. Potholes should be repaired using procedures recommended by The Asphalt Institute or other knowledgeable authorities.

Repaired areas should be properly prepared and cleaned as previously described, prior to installation of Petrotac.

Petrotac Placement: Patching over local areas of distress is accomplished as follows:

1. Position a roll of Petrotac, with release sheet attached, so as to begin coverage of the distressed area. Allow at least a six-inch extension of the Petrotac to overlap sound pavement adjoining the patch.

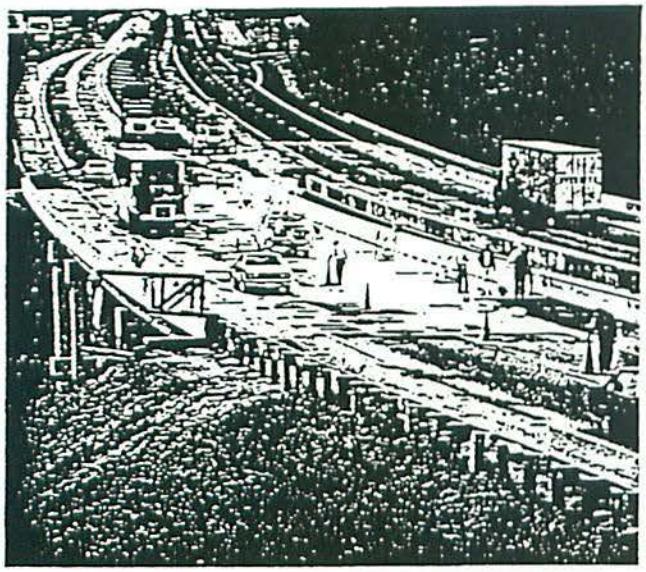
2. Unroll, removing the release sheet.

3. Allow an overlap of about two inches if adjacent Petrotac panels are needed to cover the distressed area being treated.

Note: For cold weather patching, the surface area to be patched may be heated with a torch to remove moisture and insure proper adhesion. The adhesive side of the Petrotac may be *lightly* warmed also. Do not heat the fabric side.

BRIDGE DECK MEMBRANE

Petrotac is manufactured in 36-inch-wide strips to provide full coverage installation across the width of a bridge deck. The Petrotac provides an impermeable membrane to waterproof the deck by preventing intrusion of moisture and de-icing salts into the reinforced concrete structure. Installation is as follows:



1. Prepare the deck surface in accordance with previously described procedures and applicable specifications.

Note: For optimum Petrotac adhesion, a reasonably smooth deck surface is important. A leveling course installed over a milled or highly textured surface will satisfy this requirement. Further, an open graded leveling course will provide a porous interlayer which will minimize possible "bubbling" due to deck breathing.

2. Apply a prime coat as specified. Because bridge decks tend to generate moisture during heating and cooling cycles, a primer is recommended prior to placing Petrotac.

3. Install the Petrotac strips, using laydown procedures identical to those described under PLACEMENT PROCEDURE. Start at one curb and work toward center of the bridge. On a superelevated deck start from lower curb so that fabric overlaps are in the direction of water run-off.

4. Adjacent panels of Petrotac are overlapped approximately four inches (overlap line is marked on the Petrotac). Overlapping sections must be clean and dry.

5. Trowel a bead of mastic or other suitable sealing compound along the edge of the fabric at the curb. Mastic is also recommended in areas where adjacent panels overlap end of roll overlaps or where construction techniques indicate additional sealing is necessary. This procedure will help insure a watertight seam in all areas.

A list of suitable elastomeric mastics that have been evaluated by Phillips Fibers is available.

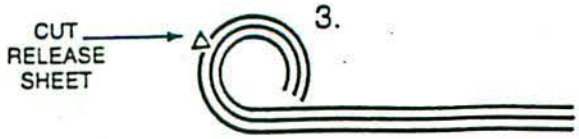
PLACEMENT PROCEDURE

Directional alignment of the Petrotac strips is often critical, and placement will be facilitated by the following procedure:

1. Position the roll over the joint or upon the surface area to be treated.

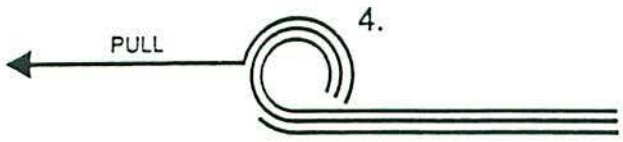
2. Unroll 20 to 25 feet, sufficient to establish direction, with the release sheet still attached.

3. Cut the release sheet with a utility blade, as indicated, being careful not to cut the Petrotac membrane.



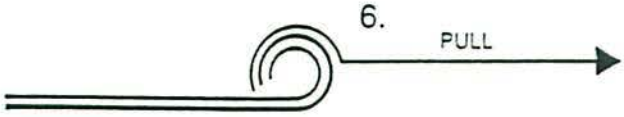
PETROTAC *Installation Procedures*

4. Pull the top portion of the release sheet towards you, exposing and unrolling the asphaltic membrane in the direction indicated. Often a rope can be used to facilitate unrolling.



5. Re-roll the 20 to 25 foot strip initially placed.

6. Follow the same release sheet removal procedure in the opposite direction, completing the laydown.



Note: Overlaps should be two inches minimum at end of roll and in the direction of traffic (four inch minimum for bridge decks).

7. Roll up the removed release paper and store in empty carton to facilitate clean-up.

8. Pneumatically roll to insure good contact and adhesion to the pavement surface. Bubbles or wrinkles should be slit and smoothed.

JOINT/CRACK REPAIR

Petrotac Placement: Once the pavement has been properly prepared the Petrotac membrane is installed as follows:

1. Center the roll of Petrotac over the joint or crack to be treated, release sheet still attached. Allow for a material overrun of four to six inches beyond the end of the joint or crack to insure waterproofing at this point.

2. Unroll, cut the release sheet, and install the Petrotac strip as previously described under PLACEMENT PROCEDURE, or as noted below.

Note: On transverse joints where one lane is open to traffic, pre-cut each Petrotac strip to required length and re-roll. Remove 12 to 18 inches of the release sheet, applying this portion to one end of the joint. By pulling the release sheet in the direction of the joint, the remainder of the strip is easily applied.

3. In the case of portland cement concrete, transverse joint strips shall be applied before longitudinal joint strips to minimize the chance of the membrane peeling if traffic is allowed prior to overlaying.

TRAFFICKING PETROTAC

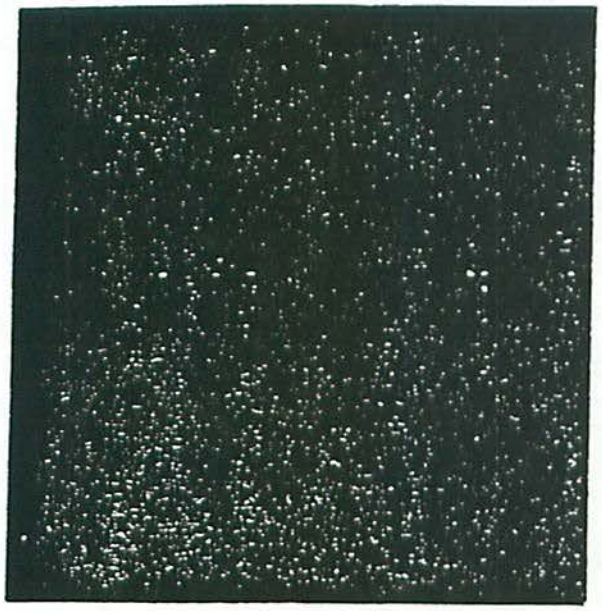
Petrotac strips, properly installed and bonded to the pavement surface, may be opened to traffic for a reasonable period. For large patched areas and longitudinal joints in particular, however, it is recommended that trafficking be limited to two weeks. *Should the Petrotac become wet during this period, traffic should be advised that the membrane may become slippery and speed should be appropriately reduced.*

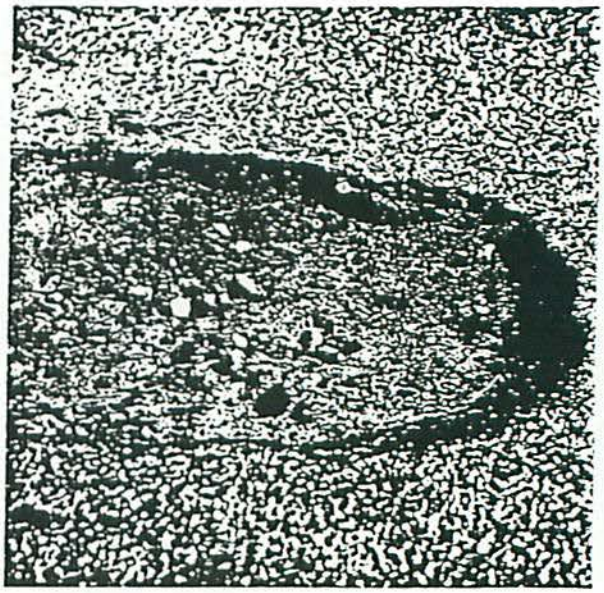
APPLICATION OF SURFACE COURSE

Tack Coat: A standard pre-paving tack coat is applied over the Petrotac and the rest of the pavement before hot mix overlay is placed. A rate of about 0.05 gallons per square yard *residual* asphalt is recommended.

Minimum Overlay Thickness: The paving mix should be applied as specified. However, a compacted thickness of less than 1½ inches is not recommended.

PETROTAC





Especially designed for P(

TYPICAL PROPERTIES

PROPERTY	TYPICAL VALUE	TEST METHOD
Grab tensile, lbs	245	ASTM D4632
Elongation, %	80	ASTM D4632
Strip tensile, lbs/in	50 (minimum)	ASTM D882 (modified)
Puncture resistance, lbs	200 (minimum)	ASTM E154
Permeance, Perms	0.10 (max)	ASTM E96 method B
Pliability @ -4° F, Mandrel bend, 180° bend at 2 seconds	No cracks in fabric or rubberized asphalt coating	ASTM D146 (modified)

PETROTAC®

NONWOVEN PHILLIPS 66 FABRIC

is a unique double-coated fabric which complements the Petromat System.

oints • Local Distress Areas • Bridge Decks

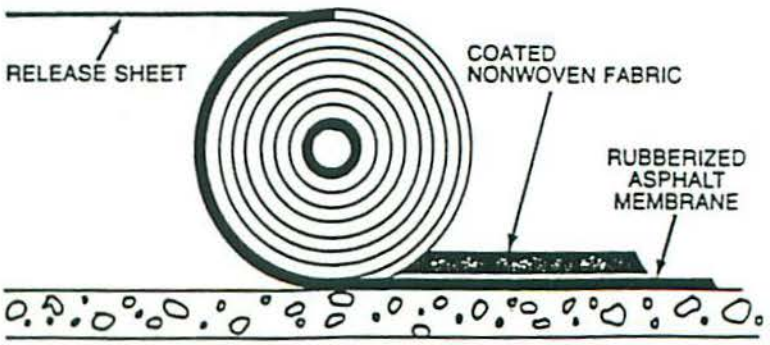
LIKE PETROMAT. . .

Petrotac serves as a waterproofing and stress absorbing membrane.

UNLIKE PETROMAT. . .

Petrotac requires no distributor equipment for pre-application of asphaltic sealant materials.

- Prevents surface moisture intrusion into pavement base structures
- And thereby reduces subgrade deterioration from erosion, freeze/thaw damage.
- Strong and durable
- Sticks readily
- Easy and inexpensive to install
- Stretches to span growing cracks without breaking
- Delays reflective cracking
- Can withstand trafficking for a reasonable time



PETROTAC®

CASE HISTORY

Pre-Coated Nonwoven Fabric

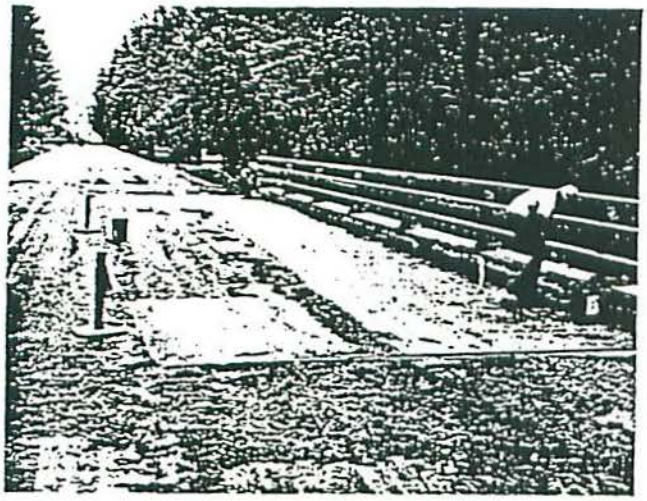
No. 7 July 1984

PROJECT: Bridge deck repair, Santiam Highway, east of Sweet Home, Oregon.

PROBLEM: How to prevent surface moisture from penetrating the deck. How to reduce deterioration caused by salt penetration. How to delay reflective cracking.

SOLUTION: Overlay deck with Petrotac BDG (Bridge Deck Grade), a unique waterproofing membrane comprised of durable Petromat, a polypropylene nonwoven fabric, precoated with a rubberized asphalt adhesive base.

Inclusion of Petrotac prevents surface moisture from penetrating and delays reflective cracking.

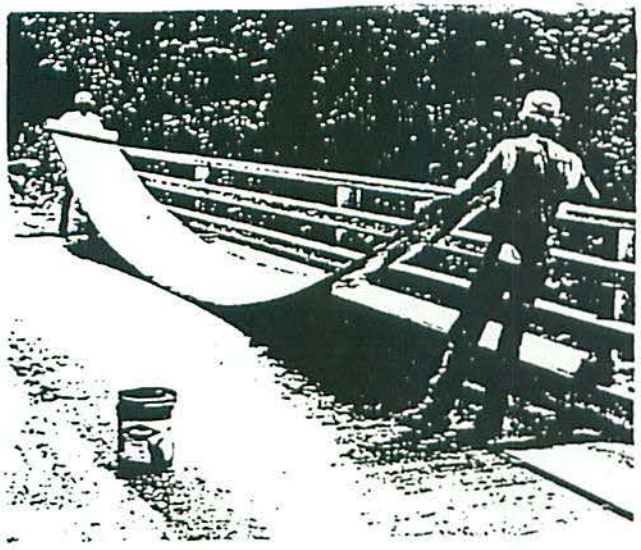


Priming the new concrete and applying mastic along the curb.

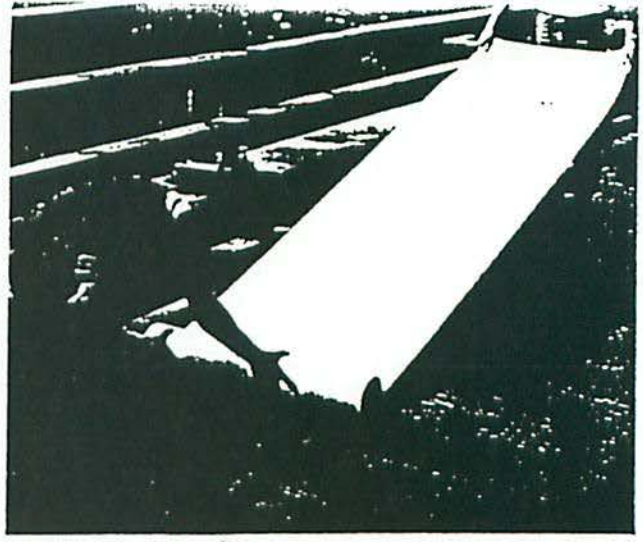
Applying mastic.

METHOD OF INSTALLATION:

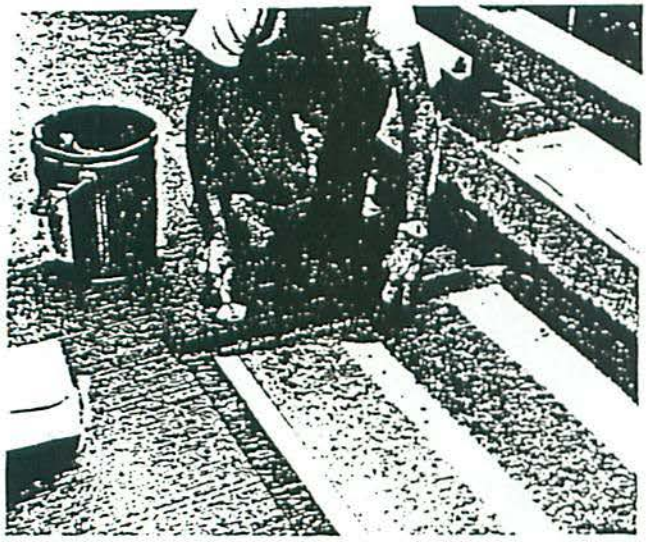
1. First the contractor aplied a primer to the new concrete.
2. Mastic was applied along the curb.
3. A roll (45' in length) of 3' wide Petrotac was unrolled and positioned along the curb.
4. Then Petrotac was rolled up halfway; the contact paper cut and removed; and Petrotac was reapplied to the concrete surface.
5. To insure a good seal, the end of each roll was coated with mastic or asphalt cement.
6. Each roll of Petrotac overlays the adjacent strip approximately 3 inches.



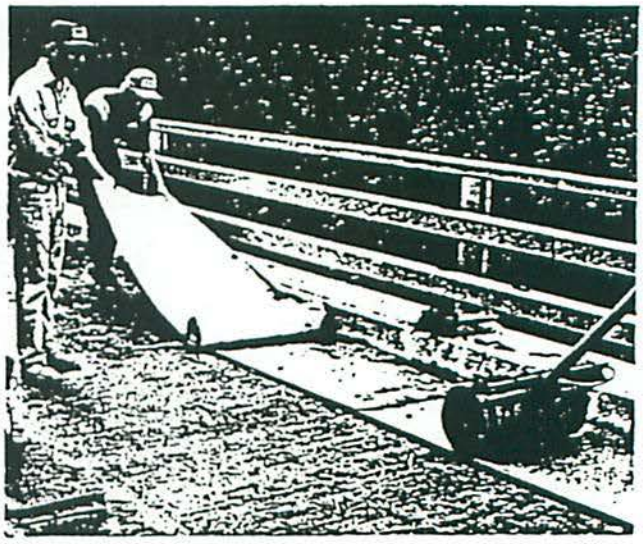
Unrolling Petrotac. Note it is lightweight and easy to handle.



Removing contact paper making sure the edge of the roll is aligned with the previous strip.



Sealing the end of a roll with mastic.



Pressing Petrotac firmly onto the cement bridge deck with a roller.

PETROTAC®
PRECOATED
NONWOVEN 66 FABRIC

PHILLIPS FIBERS CORPORATION

A SUBSIDIARY OF PHILLIPS 66 COMPANY
ENGINEERED PRODUCTS MARKETING, P.O. BOX 66, GREENVILLE, SC 29602, (803) 242-6600

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EASTERN ZONE
Post Office Box 66
Greenville, SC 29602
(803) 242-6600
(800) 845-5737

SPECIFICATION

3/90

PETROTAC*

Description:

A nonwoven needlepunched polypropylene fabric reinforced with rubberized asphalt mastic on the bottom side and precoated with asphalt on the top surface to provide high degree of adhesion between the membrane and the wearing surface. The bottom side due to high adhesive qualities is attached to release paper which is removed at the time of installation.

Properties	Minimum Value (Except as Noted)	Test Method
Thickness, mils	65	ASTM D-1777
Strip tensile, lbs/in.	50	ASTM D-882 (modified for 1" spacing between grips)
Puncture resistance, lbs	200	ASTM E-154
Permeance -Perms	0.10 (max.)	ASTM E-96 Method B
Pliability - 1/4" mandrel 180° bend @ -25°F	no cracks in fabric or rubberized asphalt	ASTM D-146

Use:

To be applied in strips over cracks and joints of Portland Cement concrete or bituminous concrete pavements. The fabric adheres to the existing surface, the fabric is then overlayed with the bituminous concrete overlay by using standard paving procedures.

Purpose:

Waterproof pavements, joints and cracks and also assists in reducing reflection cracking through stress dissipation.

Installation:

The temperature shall be at least 45°F and rising. Pavement surface must be sufficiently dry to prevent moisture migration from within, shall be free of dust, and vegetation. Cracks greater than 3/8" in width shall be filled with suitable crack filler. If necessary, Portland Cement concrete slabs shall be stabilized. The fabric shall be centered over joints and cracks to be treated and then shall be rolled. Transverse joints and cracks shall be treated before longitudinal joints. Should a crack require more than one strip, the strips shall be overlapped at least two inches in the direction of paving. No prime coat is needed when dry pavement temperature is 70°F or above. Use of a primer is recommended if pavement temperature is below 70°F.

Traffic may be allowed on the fabric for a reasonable period of time prior to application of tack coat and overlay.

A standard tack coat shall be applied over pavement and Petrotac. If emulsions are used for the tack coat, it is very important that the asphalt is allowed to break completely. Paving mix should be applied as specified; however, an overlay thickness of less than 1-1/2" is not recommended.

*Trademark Phillips Petroleum Company

PRODUCT #9000-S #9000-SH
HOT APPLIED CRACK FILLER

KOCH

KOCH MATERIALS COMPANY

COATINGS & SEALANTS DIVISION

Description

Product 9000 is a hot applied crack filler consisting of asphalt, granulated vulcanized rubber, virgin rubber, fillers, and plasticizers. The crack filler is furnished as a solid, and at application temperature is self-leveling.

Applicable Specifications

Product 9000 meets or exceeds most state DOT asphalt rubber crack filler performance specifications.

Recommended Use

Product 9000 is recommended as a maintenance crack filler for filling cracks in Portland Cement Concrete and asphaltic concrete pavement.

Application Temperatures

Heat material to between 350° F (177° C) to 400° F (204° C) before application of crack filler.
NOTE: *

Physical Properties and Composite Technical Data

	9000-S	9000-SH
Ground Rubber Content	Min. 13%	Min. 13%
Virgin Polymer Rubber	Min. 2%	Min. 2%
Flash Point COC	Min. 550° F (288° C)	Min. 550° F (288° C)
Cone Penetration @ 77° F, 150 g., 5 sec. (ASTM D-3407)	Min. 30 dmm	Min. 30 dmm
Softening Point	Min. 180° F (82.2° C)	Min. 180° F (82.2° C)
Resilience Percent (ASTM D-3407)	Min. 35	Min. 30
Ductility 39.2° F (4° C)	Min. 12 cm	Min. 10 cm
Brookfield Viscosity 375° F (190.5° C)	Min. 80 Poise	Min. 80 Poise
Bond, ½ inch Spec - 50% Ext. 20° F (-6° C)	Pass	Pass
Asphalt Compatibility (ASTM D-3407)	Pass	Pass
Pouring Consistency	Self-leveling	Self-leveling

Physical properties melted in accordance to ASTM D-3407.

* It is not necessary to hold sealant at pouring temperature to allow asphalt and rubber reaction. Koch Product 9000 Series is reacted prior to packaging.

KOCH MATERIALS COMPANY LOCATIONS:
MANUFACTURING PLANTS: NORTHUMBERLAND, PENNSYLVANIA • Penn Central Railroad Yard • 800/521-8683
STROUD, OKLAHOMA • Highway 66 East of Stroud • 800/654-9162

APPENDIX C

TEST SPECIFICATIONS

ASTM Designation: D 5084 – 90

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia, Pa. 19103

Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter[1]

This standard is issued under the fixed designation D 5084; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers laboratory measurement of the hydraulic conductivity (also referred to as *coefficient of permeability*) of water-saturated porous materials with a flexible wall permeameter.

1.2 This test method may be utilized with undisturbed or compacted specimens that have a hydraulic conductivity less than or equal to 1×10^{-5} m/s (1×10^{-3} cm/s).

1.3 The hydraulic conductivity of materials with hydraulic conductivities greater than 1×10^{-5} m/s may be determined by Test Method D 2434.

1.4 The values stated in SI units are to be regarded as the standard, unless other units are specifically given. By tradition in U.S. practice, hydraulic conductivity is reported in centimetres per second, although the common SI units for hydraulic conductivity are metres per second.

1.5 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[2]

D 1557 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop[2]

D 1587 Practice of Thin-Walled Tube Sampling of Soils[3]

D 2113 Practice for Diamond Core Drilling for Site Investigation[3]

D 2216 Method for Laboratory Determination of Water (Moisture) Content in Soil, Rock, and Soil-Aggregate Mixtures[3]

D 2434 Test Method for Permeability of Granular Soils (Constant Head)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4753 Specification for Evaluating, Selecting and Specifying Balances and Scales for Use in Soil and Rock Testing[2]

D 4767 Test Method for Consolidated-Undrained Triaxial Compression[2]

E 145 Specification for Gravity-Convection and Forced-Ventilation Ovens[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *hydraulic conductivity, k*—the rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions (20°C).

DISCUSSION—The term *coefficient of permeability* is often used instead of *hydraulic conductivity*, but *hydraulic conductivity* is used exclusively in this test method. A more complete discussion of the terminology associated with Darcy's law is given in the literature.[4]

3.1.2 *pore volume of flow*—the cumulative quantity of flow into a test specimen divided by the volume of voids in the specimen.

3.1.3 For definitions of other terms used in this test method, see Terminology D 653.

4. Significance and Use

4.1 This test method applies to one-dimensional, laminar flow of water within porous materials such as soil and rock.

4.2 The hydraulic conductivity of porous materials generally decreases with an increasing amount of air in the pores of the material. This test method applies to water-saturated porous materials containing virtually no air.

4.3 This test method applies to permeation of porous materials with water. Permeation with other liquids, such as chemical wastes, can be accomplished using procedures similar to those described in this test method. However, this test method is only intended to be used when water is the permeant liquid.

4.4 It is assumed that Darcy's law is valid and that the hydraulic conductivity is essentially unaffected by hydraulic gradient. The validity of Darcy's law may be evaluated by measuring the hydraulic conductivity of the specimen at three hydraulic gradients; if all measured values are similar (within about 25 %), then Darcy's law may be taken as valid. However, when the hydraulic gradient acting on a test

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.04 on Hydrologic Properties of Soil and Rocks.

Current edition approved June 29, 1990. Published October 1990.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

[4] Olson, R. E., and Daniel, D. E., "Measurement of the Hydraulic Conductivity of Fine-Grained Soils," *Symposium on Permeability and Groundwater Contaminant Transport, ASTM STP 746*, ASTM, 1981, pp. 18–64.

specimen is changed, the state of stress will also change, and, if the specimen is compressible, the volume of the specimen will change. Thus, some change in hydraulic conductivity may occur when the hydraulic gradient is altered, even in cases where Darcy's law is valid.

4.5 This test method provides a means for determining hydraulic conductivity at a controlled level of effective stress. Hydraulic conductivity varies with varying void ratio, which in turn changes when the effective stress changes. If the void ratio is changed, the hydraulic conductivity of the test specimen will likely change. To determine the relationship between hydraulic conductivity and void ratio, the hydraulic conductivity test would have to be repeated at different effective stresses.

4.6 The correlation between results obtained with this test method and the hydraulic conductivities of in-place field materials has not been fully investigated. Experience has sometimes shown that flow patterns in small test specimens do not necessarily follow the same patterns on large field scales and that hydraulic conductivities measured on small test specimens are not necessarily the same as larger-scale values. Therefore, the results should be applied to field situations with caution and by qualified personnel.

5. Apparatus

5.1 *Hydraulic System*—Constant head (Method A), falling head (Methods B and C), or constant rate of flow (Method D) systems may be utilized provided they meet the criteria outlined as follows:

5.1.1 *Constant Head*—The system must be capable of maintaining constant hydraulic pressures to within ±5 % and shall include means to measure the hydraulic pressures to within the prescribed tolerance. In addition, the head loss across the test specimen must be held constant to within ±5 % and shall be measured with the same accuracy or better. Pressures shall be measured by a pressure gage, electronic pressure transducer, or any other device of suitable accuracy.

5.1.2 *Falling Head*—The system shall allow for measurement of the applied head loss, thus hydraulic gradient, to within 5 % or better at any time. In addition, the ratio of initial head loss divided by final head loss over an interval of time shall be measured such that this computed ratio is accurate to within ±5 %. The head loss shall be measured with a pressure gage, electronic pressure transducer, engineer's scale, graduated pipette, or any other device of suitable accuracy. Falling head tests may be performed with either a constant tailwater elevation (Method B) or a rising tailwater elevation (Method C).

5.1.3 *Constant Rate of Flow*—The system must be capable of maintaining a constant rate of flow through the specimen to within 5 % or better. Flow measurement shall be by calibrated syringe, graduated pipette, or other device of suitable accuracy. The head loss across the specimen shall be measured to an accuracy of 5 % or better using an electronic pressure transducer or other device of suitable accuracy. More information on testing with a constant rate of flow is given in the literature.[3]

[3] Olson, R. W., Morin, R. H., and Nichols, R. W., "Flow Pump Applications in Triaxial Testing," *Symposium on Advanced Triaxial Testing of Soil and Rock, ASTM STP 977*, ASTM, 1988, pp. 68-81.

5.1.4 *System De-airing*—The hydraulic system shall be designed to facilitate rapid and complete removal of free air bubbles from flow lines.

5.1.5 *Back Pressure System*—The hydraulic system shall have the capability to apply back pressure to the specimen to facilitate saturation. The system shall be capable of maintaining the applied back pressure throughout the duration of hydraulic conductivity measurements. The back pressure system shall be capable of applying, controlling, and measuring the back pressure to 5 % or better of the applied pressure. The back pressure may be provided by a compressed gas supply, a deadweight acting on a piston, or any other method capable of applying and controlling the back pressure to the tolerance prescribed in this paragraph.

NOTE 1—Application of gas pressure directly to a fluid will dissolve gas in the fluid. A variety of techniques are available to minimize dissolution of gas in the back pressure fluid, including separation of gas and liquid phases with a bladder and frequent replacement of the liquid with de-aired water.

5.2 *Flow Measurement System*—Both inflow and outflow volumes shall be measured unless the lack of leakage, continuity of flow, and cessation of consolidation or swelling can be verified by other means. Flow volumes shall be measured by a graduated accumulator, graduated pipette, vertical standpipe in conjunction with an electronic pressure transducer, or other volume-measuring device of suitable accuracy.

5.2.1 *Flow Accuracy*—Required accuracy for the quantity of flow measured over an interval of time is 5 % or better.

5.2.2 *De-airing and Compliance of the System*—The flow-measurement system shall contain a minimum of dead space and be capable of complete and rapid de-airing. Compliance of the system in response to changes in pressure shall be minimized by using a stiff flow measurement system. Rigid tubing, such as metallic or rigid thermoplastic tubing, shall be used.

5.2.3 *Head Losses*—Head losses in the tubes, valves, porous end pieces, and filter paper may lead to error. To guard against such errors, the permeameter shall be assembled with no specimen inside and then the hydraulic system filled. If a constant or falling head test is to be used, the hydraulic pressures or heads that will be used in testing a specimen shall be applied, and the rate of flow measured with an accuracy of 5 % or better. This rate of flow shall be at least ten times greater than the rate of flow that is measured when a specimen is placed inside the permeameter and the same hydraulic pressures or heads are applied. If a constant rate of flow test is to be used, the rate of flow to be used in testing a specimen shall be supplied to the permeameter and the head loss measured. The head loss without a specimen shall be less than 0.1 times the head loss when a specimen is present.

5.3 *Permeameter Cell Pressure System*—The system for pressurizing the permeameter cell shall be capable of applying and controlling the cell pressure to within 5 % of the applied pressure. However, the effective stress on the test specimen (which is the difference between the cell pressure and the pore water pressure) shall be maintained to the desired value with an accuracy of 10 % or better. The device for pressurizing the cell may consist of a reservoir connected to the permeameter cell and partially filled with de-aired

water, with the upper part of the reservoir connected to a compressed gas supply or other source of pressure (see Note 2). The gas pressure shall be controlled by a pressure regulator and measured by a pressure gage, electronic pressure transducer, or any other device capable of measuring to the prescribed tolerance. A hydraulic system pressurized by deadweight acting on a piston or any other pressure device capable of applying and controlling the permeameter cell pressure to the tolerance prescribed in this paragraph may be used.

NOTE 2—De-aired water is commonly used for the cell fluid to minimize potential for diffusion of air through the membrane into the specimen. Other fluids, such as oils, which have low gas solubilities are also acceptable, provided they do not react with components of the permeameter. Also, use of a long (approximately 5 to 7 m) tube connecting the pressurized cell liquid to the cell helps to delay the appearance of air in the cell fluid and to reduce the flux of dissolved air into the cell.

5.4 *Permeameter Cell*—An apparatus shall be provided in which the specimen and porous end pieces, enclosed by a membrane sealed to the cap and base, are subjected to controlled fluid pressures. A schematic diagram of a typical cell is shown in Fig. 1.

5.4.1 The permeameter cell may allow for observation of changes in height of the specimen, either by observation through the cell wall using a cathetometer or other instrument, or by monitoring of either a loading piston or an extensometer extending through the top plate of the cell bearing on the top cap and attached to a dial indicator or other measuring device. The piston or extensometer should pass through a bushing and seal incorporated into the top plate and shall be loaded with sufficient force to compensate for the cell pressure acting over the cross-sectional area of the piston where it passes through the seal. If deformations are measured, the deformation indicator shall be a dial indicator or cathetometer graduated to 0.3 mm (0.01 in.) or better and having an adequate travel range. Any other measuring device meeting these requirements is acceptable.

5.4.2 In order to facilitate gas removal, and thus saturation of the hydraulic system, four drainage lines leading to the specimen, two each to the base and top cap, are recommended. The drainage lines shall be controlled by no-volume-change valves, such as ball valves, and shall be designed to minimize dead space in the lines.

5.5 *Top Cap and Base*—An impermeable, rigid top cap and base shall be used to support the specimen and provide for transmission of permeant liquid to and from the specimen. The diameter or width of the top cap and base shall be equal to the diameter or width of the specimen ±5 %. The base shall prevent leakage, lateral motion, or tilting, and the top cap shall be designed to receive the piston or extensometer, if used, such that the piston-to-top cap contact area is concentric with the cap. The surface of the base and top cap that contacts the membrane to form a seal shall be smooth and free of scratches.

5.6 *Flexible Membranes*—The flexible membrane used to encase the specimen shall provide reliable protection against leakage. The membrane shall be carefully inspected prior to use and if any flaws or pinholes are evident, the membrane shall be discarded. To minimize restrain to the specimen, the diameter or width of the unstretched membrane shall be

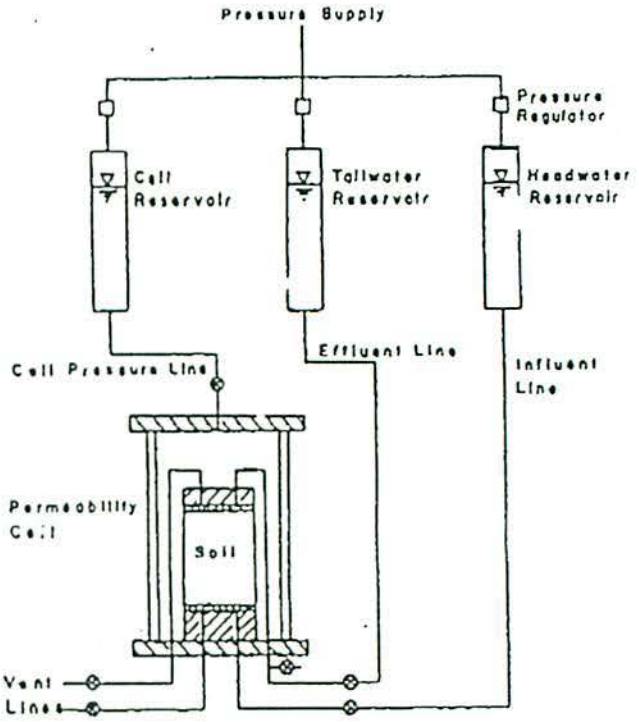

FIG. 1 Permeameter Cell

between 90 and 95 % of that of the specimen. The membrane shall be sealed to the specimen base and cap with rubber O-rings for which the unstressed, inside diameter or width is less than 90 % of the diameter or width of the base and cap, or by any other method that will produce an adequate seal.

NOTE 3—Membranes may be tested for flaws by placing them around a form sealed at both ends with rubber O-rings, subjecting them to a small air pressure on the inside, and then dipping them into water. If air bubbles come up from any point on the membrane, or if any visible flaws are observed, the membrane shall be discarded.

5.7 *Porous End Pieces*—The porous end pieces shall be of silicon carbide, aluminum oxide, or other material that is not attacked by the specimen or permeant liquid. The end pieces shall have plane and smooth surfaces and be free of cracks, chips, and nonuniformities. They shall be checked regularly to ensure that they are not clogged.

5.7.1 The porous end pieces shall be the same diameter or width (±5 %) as the specimen, and the thickness shall be sufficient to prevent breaking.

5.7.2 The hydraulic conductivity of the porous end pieces shall be significantly greater than that of the specimen to be tested. The requirements outlined in 5.2.3 ensure that.

5.8 *Filter Paper*—If necessary to prevent intrusion of material into the pores of the porous end pieces, one or more sheets of filter paper shall be placed between the top and bottom porous end pieces and the specimen. The paper shall have a negligibly small hydraulic impedance. The requirements outlined in 5.2.3 ensure that the impedance is small.

5.9 *Equipment for Compacting a Specimen*—Equipment (including compactor and mold) suitable for the method of compaction specified by the requester shall be used.

5.10 *Sample Extruder*—When the material being tested is a soil core, the soil core shall usually be removed from the sampler with an extruder. The sample extruder shall be capable of extruding the soil core from the sampling tube in the same direction of travel in which the sample entered the tube and with minimum disturbance of the sample. If the soil core is not extruded vertically, care should be taken to avoid bending stresses on the core due to gravity. Conditions at the time of sample extrusion may dictate the direction of removal, but the principal concern is to keep the degree of disturbance minimal.

5.11 *Trimming Equipment*—Specific equipment for trimming the specimen to the desired dimensions will vary depending on quality and characteristics of the sample; however, the following items listed may be used: lathe, wire saw with a wire about 0.3 mm (0.01 in.) in diameter, spatulas, knives, steel rasp for very hard clay specimens, cradle or split mold for trimming specimen ends, and steel straight edge for final trimming of specimen ends.

5.12 *Devices for Measuring the Dimensions of the Specimen*—Devices used to measure the dimensions of the specimen shall be capable of measuring to the nearest 0.3 mm (0.01 in.) or better and shall be constructed such that their use will not disturb the specimen.

5.13 *Balances*—The balance shall be suitable for determining the mass of the specimen and shall be selected as discussed in Specification D 4753. The mass of specimens less than 100 g shall be determined to the nearest 0.01 g. The mass of specimens 100 g or larger shall be determined to the nearest 0.1 g. The mass of specimens >1000 g shall be determined to the nearest 1.0 g.

5.14 *Equipment for Mounting the Specimen*—Equipment for mounting the specimen in the permeameter cell shall include a membrane stretcher or cylinder, and ring for expanding and placing O-rings on the base and top cap to seal the membrane.

5.15 *Vacuum Pump*—To assist with de-airing of permeameter system and saturation of specimens.

5.16 *Temperature Maintaining Device*—The temperature of the permeameter, test specimen, and reservoir of permeant liquid shall not vary more than ±3°C (±5.7°F). Normally, this is accomplished by performing the test in a room with a relatively constant temperature. If such a room is not available, the apparatus shall be placed in a water bath, insulated chamber, or other device that maintains a temperature within the tolerance specified in 5.16. The temperature shall be periodically measured and recorded.

5.17 *Water Content Containers*—The containers shall be in accordance with Method D 2216.

5.18 *Drying Oven*—The oven shall be in accordance with Specification E 145.

6. Reagents

6.1 *Permeant Water:*

6.1.1 The permeant water is the liquid used to permeate the test specimen and is also the liquid used in backpressuring the specimen.

6.1.2 The type of permeant water should be specified by the requestor. If no specification is made, tap water shall be used for the permeant liquid. The type of water utilized shall be indicated in the report.

NOTE 4—Chemical interactions between a permeant liquid and the porous material may lead to variations in hydraulic conductivity. Distilled water can significantly lower the hydraulic conductivity of clayey soils (see the literature).[4] For this reason, distilled water is not usually recommended as a permeant liquid. A permeant liquid used by some is 0.005 N $CaSO_4$, which can be obtained for example, by dissolving 6.8 g of nonhydrated, reagent-grade $CaSO_4$ in 10 L of de-aired, distilled water. This $CaSO_4$ solution is thought to neither increase nor decrease significantly the hydraulic conductivity of clayey soils. In areas with extremely brackish tap water, the $CaSO_4$ solution is recommended.

6.1.3 *Deaired Water*—To aid in removing as much air from the test specimen as possible, deaired water shall be used. The water is usually deaired by boiling, by spraying a fine mist of water into an evacuated vessel attached to a vacuum source, or by forceful agitation of water in a container attached to a vacuum source. If boiling is used, care shall be taken not to evaporate an excessive amount of water, which can lead to a larger salt concentration in the permeant water than desired. To prevent dissolution of air back into the water, deaired water shall not be exposed to air for prolonged periods.

7. Test Specimens

7.1 *Size*—Specimens shall have a minimum diameter of 25 mm (1.0 in.) and a minimum height of 25 mm. The height and diameter of the specimen shall be measured to the nearest 0.3 mm (0.01 in.) or better. The length and diameter shall vary by no more than ±5 %. The surface of the test specimen may be uneven, but indentations must not be so deep that the length or diameter vary by more than ±5 %. The diameter and height of the specimen shall each be at least 6 times greater than the largest particle size within the specimen. If, after completion of a test, it is found based on visual observation that oversized particles are present, that information shall be indicated on the report.

NOTE 5—Most hydraulic conductivity tests are performed on cylindrical test specimens. It is possible to utilize special equipment for testing prismatic test specimens, in which case reference to "diameter" in 7.1 applies to the least width of the prismatic test specimen.

7.2 *Undisturbed Specimens*—Undisturbed test specimens shall be prepared from a representative portion of undisturbed samples secured in accordance with Practice D 1587 or Practice D 2113, and preserved and transported in accordance with requirements for Group C materials in Practice D 4220. Specimens obtained by tube sampling or coring may be tested without trimming except for cutting the end surfaces plane and perpendicular to the longitudinal axis of the specimen, provided soil characteristics are such that no significant disturbance results from sampling. Where the sampling operation has caused disturbance of the soil, the disturbed material shall be trimmed. Where removal of pebbles or crumbling resulting from trimming causes voids on the surface of the specimen that cause the length or diameter to vary by more than ±5 %, the voids shall be filled with remolded material obtained from the trimmings. The ends of the test specimen shall be cut and not troweled (troweling can seal off cracks, slickensides, or other secondary features that might conduct water flow). Specimens shall be trimmed, whenever possible, in an environment where changes in moisture content are minimized. A controlled high-humidity room is usually used for this purpose. The mass and dimensions of the test specimen shall be

determined to the tolerances given in 5.12 and 5.13. The test specimen shall be mounted immediately in the permeameter. The water content of the trimmings shall be determined in accordance with Method D 2216.

7.3 *Laboratory-Compacted Specimens*—The material to be tested shall be prepared and compacted inside a mold in a manner specified by the requestor. If the specimen is placed and compacted in layers, the surface of each previously-compacted layer shall be lightly scarified (roughened) with a fork, ice pick, or other suitable object, unless the requester specifically states that scarification is not to be performed. Test Methods D 698 and D 1557 describe two methods of compaction, but any other method specified by the requestor may be used as long as the method is described in the report. Large clods of material should not be broken down prior to compaction unless it is known that they will be broken in field construction, as well, or the requestor specifically requests that the clod size be reduced. Neither hard clods nor individual particles of the material shall exceed ⅙ of either the height or diameter of the specimen. After compaction, the test specimen shall be removed from the mold, the ends scarified, and the dimensions and weight determined within the tolerances given in 5.12 and 5.13. After the dimensions and mass are determined, the test specimen shall be immediately mounted in the permeameter. The water content of the trimmings shall be determined in accordance with Method D 2216.

7.4 *Other Preparation Methods*—Other methods of preparation of a test specimen are permitted if specifically requested. The method of specimen preparation shall be identified in the report.

7.5 After the height, diameter, mass, and water content of the test specimen have been determined, the dry unit weight shall be calculated. Also, the initial degree of saturation shall be estimated (this information may be used later in the backpressure stage).

8. Procedure

8.1 *Specimen Setup:*

8.1.1 Cut two filter paper sheets to approximately the same shape as the cross section of the test specimen. Soak the two porous end pieces and filter paper sheets, if used, in a container of permeant water.

8.1.2 Place the membrane on the membrane expander. Apply a thin coat of silicon high-vacuum grease to the sides of the end caps. Place one porous end piece on the base and place one filter paper sheet, if used, on the porous end piece, followed by the test specimen. Place the second filter paper sheet, if used, on top of the specimen followed by the second porous end piece and the top cap. Place the membrane around the specimen, and using the membrane expander or other suitable O-ring expander, place one or more O-rings to seal the membrane to the base and one or more additional O-rings to seal the membrane to the top cap.

8.1.3 Attach flow tubing to the top cap, if not already attached, assemble the permeameter cell, and fill it with de-aired water or other cell fluid. Attach the cell pressure reservoir to the permeameter cell line and the hydraulic system to the influent and effluent lines. Fill the cell pressure reservoir with deaired water, or other suitable liquid, and the hydraulic system with deaired permeant water. Apply a small confining pressure of 7 to 35 kPa (1 to 5 psi) to the cell and apply a pressure less than the confining pressure to both the influent and effluent systems, and flush permeant water through the flow system. After all visible air has been removed from the flow lines, close the control valves. At no time during saturation of the system and specimen or hydraulic conductivity measurements shall the maximum applied effective stress be allowed to exceed that to which the specimen is to be consolidated.

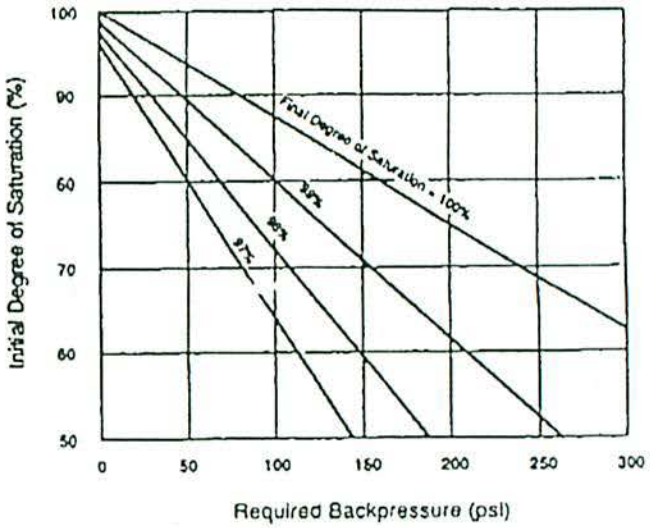

FIG. 2 Back Pressure to Attain Various Degrees of Saturation[4]

8.2 *Specimen Soaking (Optional)*—To aid in saturation, specimens may be soaked under partial vacuum applied to the top of the specimen. Atmospheric pressure shall be applied to the specimen base through the influent lines, and the magnitude of the vacuum set to generate a hydraulic gradient across the sample less than that which will be used during hydraulic conductivity measurements.

NOTE 6—Soaking under vacuum is applicable when there are continuous air voids in the specimen. Soaking under vacuum is only recommended for test specimens with initial degrees of saturation below 70 %. The specimen may swell when exposed to water; the effective stress will tend to counteract the swelling. However, for materials that tend to swell, unless the applied effective stress is greater than or equal to the swell pressure, the specimen will swell.

8.3 *Backpressure Saturation*—To saturate the specimen, backpressuring is usually necessary. Figure 2 provides guidance on back pressure required to attain saturation.

NOTE 7—Figure 2 assumes that the water used for back pressure is deaired and that the only source for air to dissolve into the water is air from the test specimen. If air pressure is used to control the back pressure, pressurized air will dissolve into the water, thus reducing the capacity of the water used for back pressure to dissolve air from the pores of the test specimen. The problem is minimized by using a long (>5 m) tube that is impermeable to air between the air-water interface and test specimen, by separating the back-pressure water from the air by a material or fluid that is relatively impermeable to air, by periodically replacing the back-pressure water with deaired water, or by other means.

[4] Lowe, J., and Johnson, T. C., "Use of Back Pressure to Increase Degree of Saturation of Triaxial Test Specimens," *Proceedings, ASCE Research Conference on Shear Strength of Cohesive Soils*, Boulder, CO, 1960.

8.3.1 Open the flow line valves and flush out of the system any free air bubbles using the procedure outlined in 8.1.3. If an electronic pressure transducer or other measuring device is to be used during the test to measure pore pressures or applied hydraulic gradient, it should be bled of any trapped air. Take and record an initial reading of specimen height, if being monitored.

8.3.2 Adjust the applied confining pressure to the value to be used during saturation of the sample. Apply backpressure by simultaneously increasing the cell pressure and the influent and effluent pressures in increments. The maximum value of an increment in backpressure shall be sufficiently low so that no point in the specimen is exposed to an effective stress in excess of that to which the specimen will be subsequently consolidated. At no time shall a head be applied so that the effective confining stress is <7 kPa (1 psi) because of the danger of separation of the membrane from the test specimen. Maintain each increment of pressure for a period of a few minutes to a few hours, depending upon the characteristics of the specimen. To assist in removal of trapped air, a small hydraulic gradient may be applied across the specimen to induce flow.

8.3.3 Saturation shall be verified with one of the three following techniques:

8.3.3.1 Saturation may be verified by measuring the B coefficient as described in Test Method D 4767 (see Note 8). The test specimen shall be considered to be adequately saturated if (*1*) the B value is ≥0.95, or (*2*) for relatively incompressible materials, for example, rock, if the B value remains unchanged with application of larger values of back pressure. The B value may be measured prior to or after completion of the consolidation phase (see 8.4). Accurate B-value determination can only be made if no gradient is acting on the specimen and all pore pressure induced by consolidation has dissipated.

NOTE 8—The B coefficient is defined for this type of test as the change in pore water pressure in the porous material divided by the change in confining pressure. Compressible materials that are fully saturated with water will have a B value of 1.0. Relatively incompressible, saturated materials have B values which are somewhat less than 1.0.

8.3.3.2 Saturation of the test specimen may be confirmed at the completion of the test by calculation of the final degree of saturation. The final degree of saturation shall be 100 ± 5 %. However, measurement of the B coefficient as described in 8.3.3.1 or use of some other technique (8.3.3.3) is strongly recommended because it is much better to confirm saturation prior to permeation than to wait until after the test to determine if the test was valid.

8.3.3.3 Other means for verifying saturation, such as measurement of the volume change of the specimen when the pore water pressure has been changed, can be used for verifying saturation provided data are available for similar materials to establish that the procedure used confirms saturation as required in 8.3.3.1 or 8.3.3.2.

8.4 *Consolidation*—The specimen shall be consolidated to the effective stress specified by the requestor. Consolidation may be accomplished in stages, if desired.

NOTE 9—The test specimen may be consolidated prior to application of backpressure. Also, the backpressure and consolidation phases may be completed concurrently if backpressures are applied sufficiently slowly to minimize potential for overconsolidation of the specimen.

8.4.1 Record the specimen height, if being monitored, prior to application of consolidation pressure and periodically during consolidation.

8.4.2 Increase the cell pressure to the level necessary to develop the desired effective stress, and begin consolidation. Drainage may be allowed from the base or top of the specimen, or simultaneously from both ends.

8.4.3 (Optional) Record outflow volumes to confirm that primary consolidation has been completed prior to initiation of the hydraulic conductivity test. Alternatively, measurements of the change in height of the test specimen can be used to confirm completion of consolidation.

NOTE 10—The procedure in 8.4.3 is optional because the requirements of 8.5 ensure that the test specimen is adequately consolidated during permeation because if it is not, inflow and outflow volumes will differ significantly. However, for accurate B-value determination, completion of consolidation should be confirmed (see 8.3.3.1). It is recommended that outflow volumes or height changes be recorded as a means for verifying the completion of consolidation prior to initialization of permeation. Also, measurements in the change in height of the test specimen, coupled with knowledge of the initial height, provide a means for checking the final height of the specimen.

8.5 *Permeation:*

8.5.1 *Hydraulic Gradient*—When possible, the hydraulic gradient used for hydraulic conductivity measurements should be similar to that expected to occur in the field. In general, hydraulic gradients from <1 to 5 cover most field conditions. However, the use of small hydraulic gradients can lead to very long testing times for materials having low hydraulic conductivity (less than about 1×10^{-6} cm/s). Somewhat larger hydraulic gradients are usually used in the laboratory to accelerate testing, but excessive gradients must be avoided because high seepage pressures may consolidate the material, material may be washed from the specimen, or fine particles may be washed downstream and plug the effluent end of the test specimen. These effects could increase or decrease hydraulic conductivity. If no gradient is specified by the requestor, the following guidelines may be followed:

Hydraulic Conductivity, cm/s	Recommended Maximum Hydraulic Gradient
1×10^{-3} to 1×10^{-4}	2
1×10^{-4} to 1×10^{-5}	5
1×10^{-5} to 1×10^{-6}	10
1×10^{-6} to 1×10^{-7}	20
less than 1×10^{-7}	30

NOTE 11—Seepage pressures associated with large hydraulic gradients can consolidate soft, compressible specimens and reduce their hydraulic conductivity. It may be necessary to use smaller hydraulic gradients (<10) for such specimens.

8.5.2 *Initialization*—Initiate permeation of the specimen by increasing the influent pressure (see 8.3.2). The effluent pressure shall not be decreased because air bubbles that were dissolved by the specimen water during backpressuring may come out of solution if the pressure is decreased. The back pressure shall be maintained throughout the permeation phase.

8.5.3 *Constant Head Test (Method A)*—Measure and record the required head loss across the test specimen to the tolerances stated in 5.1.1 and 5.2.3. The head loss across the specimen shall be kept constant ±5 %. Measure and record periodically the quantity of inflow as well as the quantity of outflow. Also measure and record any changes in height of the test specimen, if being monitored (see Note 11). Con-

tinue permeation until at least four values of hydraulic conductivity are obtained over an interval of time in which: (*1*) the ratio of outflow to inflow rate is between 0.75 and 1.25, and (*2*) the hydraulic conductivity is steady. The hydraulic conductivity shall be considered steady if four or more consecutive hydraulic conductivity determinations fall within ±25 % of the mean value for $k \geq 1 \times 10^{-10}$ m/s or within ±50 % for $k < 1 \times 10^{-10}$ m/s, and a plot of the hydraulic conductivity versus time shows no significant upward or downward trend.

8.5.4 *Falling-Head Tests (Methods B and C)*—Measure and record the required head loss across the test specimen to the tolerances stated in 5.1.2. For falling-head tests, at no time shall the applied head loss across the specimen be less than 75 % of the initial (maximum) head loss during each individual hydraulic conductivity determination (see Note 12). Periodically measure and record any changes in the height of the specimen, if being monitored. Continue permeation until at least four values of hydraulic conductivity are obtained over an interval of time in which: (*1*) the ratio of outflow to inflow rate is between 0.75 and 1.25, and (*2*) the hydraulic conductivity is steady (see 8.5.3).

NOTE 12—When the water pressure in a test specimen changes and the applied total stress is constant, the effective stress in the test specimen changes, which can cause volume changes that can invalidate the test results. The requirement that the head loss not decrease very much is intended to keep the effective stress from changing too much. For extremely soft, compressible test specimens, even more restrictive criteria might be needed. Also, when the initial and final head losses across the test specimen do not differ by much, great accuracy is needed to comply with the requirement of 5.1.2 that the ratio of initial to final head loss be determined with an accuracy of ±5 % or better. When the initial and final head loss over an interval of time do not differ very much, it may be possible to comply with the requirements for a constant head test (8.5.3) in which the head loss must not differ by more than ±5 % and to treat the test as a constant head test.

8.5.4.1 *Test with Constant Tailwater Level (Method B)*—If the water pressure at the downstream (tailwater) end of the test specimen is kept constant, periodically measure and record either the quantity of inflow or the level of water in the influent standpipe; measure and record the quantity of outflow from the test specimen.

8.5.4.2 *Test with Increasing Tailwater Level (Method C)*—If the water pressure at the downstream end of the test specimen rises during an interval of time, periodically measure and record either the quantity or inflow and outflow or the changes in water levels in the influent and effluent standpipes.

8.5.5 *Constant Rate of Flow Tests (Method D)*—Initiate permeation of the specimen by imposing a constant flow rate. Choose the flow rate so the hydraulic gradient does not exceed the value specified, or if none is specified, the value recommended in 8.5.1. Periodically measure the rate of inflow, the rate of outflow, and head loss across the test specimen to the tolerances given in 5.1.3. Also, measure and record any changes in specimen height, if being monitored. Continue permeation until at least four values of hydraulic conductivity are obtained over an interval of time in which (*1*) the ratio of inflow to outflow rates is between 0.75 and 1.25, and (*2*) hydraulic conductivity is steady (see 8.5.3).

8.6 *Final Dimensions of the Specimen*—After completion of permeation, reduce the applied confining, influent, and effluent pressures in a manner that does not generate significant volume change of the test specimen. Then carefully disassemble the permeater cell and remove the specimen. Measure and record the final height, diameter, and total mass of the specimen. Then determine the final water content of the specimen by the procedure of Method D 2216. Dimensions and mass of the test specimen shall be measured to the tolerances specified in 5.13 and 7.1.

NOTE 13—The specimen may swell after removal of back pressure as a result of air coming out of solution. A correction may be made for this effect, provided that changes in the length of the specimen are monitored during the test. The strain caused by dismantling the cell is computed from the length of the specimen before and after dismantling the cell. The same strain is assumed to have occurred in the diameter. The corrected diameter and actual length before the back pressure was removed are used to compute the volume of the test specimen prior to dismantling the cell. The volume prior to dismantling the cell is used to determine the final dry density and degree of saturation.

9. Calculation

9.1 *Constant Head and Constant Rate of Flow Tests (Methods A and D)*—Calculate the hydraulic conductivity, k, as follows:

$$k = QL/Ath \tag{1}$$

where:

k = hydraulic conductivity, m/s,
Q = quantity of flow, taken as the average of inflow and outflow, m^3,
L = length of specimen along path of flow, m,
A = cross-sectional area of specimen, m^2,
t = interval of time, s, over which the flow Q occurs, and
h = difference in hydraulic head across the specimen, m of water.

9.2 *Falling-Head Tests:*

9.2.1 *Constant Tailwater Pressure (Method B)*—Calculate the hydraulic conductivity, k, as follows:

$$k = \frac{aL}{At} \ln\left(\frac{h_1}{h_2}\right) \tag{2}$$

where:

a = cross-sectional area of the reservoir containing the influent liquid, m^2,
L = length of the specimen, m,
A = cross-sectional area of the specimen, m^2,
t = elapsed time between determination of h_1 and h_2, s,
h_1 = head loss across the specimen at time t_1, m, and
h_2 = head loss across the specimen at time t_2, m.

9.2.2 *Increasing Tailwater Pressure (Method C)*—Calculate the hydraulic conductivity, k, as follows:

$$k = \frac{a_{in}\, a_{out}\, L}{A\, t\, (a_{in} + a_{out})} \ln(h_1/h_2) \tag{3}$$

where:

a_{in} = cross-sectional area of the reservoir containing the influent liquid, m^2,
a_{out} = cross-sectional area of the reservoir containing the effluent liquid, m^2,
L = length of the specimen, m,
A = cross-sectional area of the specimen, m^2,
t = elapsed time between determination of h_1 and h_2, s,
h_1 = head loss across the specimen at time t, m, and
h_2 = head loss across the specimen at time t_2, m.

NOTE 14—For the case in which $a_{out} = a_{in} = a$, the equation for calculating k for a falling head test with a rising tailwater level is:

$$k = \frac{a\,L}{-2\,A\,t} \ln\left(\frac{h_1}{h_2}\right) \quad (4)$$

9.3 Correct the hydraulic conductivity to that for 20°C (68°F), k_{20}, by multiplying k by the ratio of the viscosity of water at test temperature to the viscosity of water at 20°C (68°F), R_T, from Table 1, as follows:

$$k_{20} = R_T k \quad (5)$$

TABLE 1 Correction Factor R_T for Viscosity of Water at Various Temperatures[A]

Temperature, °C	R_T	Temperature, °C	R_T
0	1.783	25	0.889
1	1.723	26	0.869
2	1.664	27	0.850
3	1.611	28	0.832
4	1.560	29	0.814
5	1.511	30	0.797
6	1.465	31	0.781
7	1.421	32	0.765
8	1.379	33	0.749
9	1.339	34	0.733
10	1.301	35	0.719
11	1.265	36	0.705
12	1.230	37	0.692
13	1.197	38	0.678
14	1.165	39	0.665
15	1.135	40	0.653
16	1.106	41	0.641
17	1.077	42	0.629
18	1.051	43	0.618
19	1.025	44	0.607
20	1.000	45	0.598
21	0.978	46	0.585
22	0.953	47	0.575
23	0.931	48	0.566
24	0.910	49	0.558

[A] $R_T = (-0.02452\,T + 1.495)$ where T is the degrees celsius

10. Report

10.1 Report the following information:

10.1.1 Sample identifying information,

10.1.2 Any special selection and preparation process, such as removal of stones or other materials, or indication of their presence, if undisturbed specimen,

10.1.3 Descriptive information on method of compaction,

10.1.4 Initial dimensions of the specimen,

10.1.5 Initial water content and dry unit weight of the specimen,

10.1.6 Type of permeant liquid used,

10.1.7 Magnitude of total back pressure,

10.1.8 Maximum and minimum effective consolidation stress,

NOTE 15—The maximum effective stress exists at the effluent end of the test specimen and the minimum stress at the influent end.

10.1.9 Height of specimen after completion of consolidation, if monitored,

10.1.10 Range of hydraulic gradient used,

10.1.11 Final length, diameter, water content, dry unit weight, and degree of saturation of the test specimen,

10.1.12 Average hydraulic conductivity for the last four determinations of hydraulic conductivity (obtained as described in 8.5.3 to 8.5.5), reported with two significant figures, for example, 7.1×10^{-10} m/s, and reported in units of m/s (plus additional units, if requested or customary),

10.1.13 Graph or table of hydraulic conductivity versus time or pore volumes of flow is recommended.

11. Precision and Bias

11.1 *Precision*—Data are being evaluated to determine the precision of this test method. In addition, Subcommittee D18.04 on Hydrologic Properties of Soil and Rocks, is seeking pertinent data from users of this test method.

11.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

12. Keywords

12.1 coefficient of permeability; hydraulic barriers; hydraulic conductivity; liner; permeameter

1994 Standard Specifications

for Road, Bridge,
and Municipal Construction

Washington State Department of Transportation

American Public Works Association
Washington State Chapter

7-17.3(4) Cleaning and Testing

7-17.3(4)A General

Sewers and appurtenances, where required in the Plans, shall be cleaned and tested after backfilling by either the exfiltration or low pressure air method at the option of the Contractor, except where the ground water table is such that the Engineer may require the infiltration test.

All work involved in cleaning and testing sewer lines between manholes or rodding inlets as required herein shall be completed within fifteen working days after backfilling of sewer lines and structures. Any further delay will require the written consent of the Engineer. The Contractor shall furnish all labor, materials, tools, and equipment necessary to make the test, clean the lines, and perform all work incidental thereto. The Contractor shall perform the tests under the direction and in the presence of the Engineer. Precautions shall be taken to prevent joints from drawing during tests, and any damage resulting from these tests shall be repaired by the Contractor at no expense to the Contracting Agency. The manner and time of testing shall be subject to approval by the Engineer.

All wyes, tees, and stubs shall be plugged with flexible jointed caps, or acceptable alternate, securely fastened to withstand the internal test pressure. Such plugs or caps shall be readily removable, and their removal shall provide a socket suitable for making a flexible jointed lateral connection or extension.

If the Contractor elects to test large diameter pipe one joint at a time, leakage allowances shall be converted from GPM per 100 feet to GPM per joint by dividing by the number of joints occurring in 100 feet. If leakage exceeds the allowable amount, corrective measures shall be taken and the line then retested to the satisfaction of the Engineer.

Testing side sanitary sewers shall be for their entire length from the public sewer in the street to the connection with the building's plumbing. Their testing shall be as required by the local sanitary agency but in no case shall it be less thorough than that of filling the pipe with water before backfilling and visually inspecting the exterior for leakage. The decision of the Engineer as to acceptance of the side sanitary sewer shall be final.

If any sewer installation fails to meet the requirements of the test method used, the Contractor shall determine, at no expense to the Contracting Agency, the source or sources of leakage and shall repair or replace all defective materials or workmanship at no expense to the Contracting Agency. The complete pipe installation shall meet the requirements of the test method used before being considered acceptable.

7-17.3(4)B Exfiltration Test

Prior to making exfiltration leakage tests, the Contractor may fill the pipe with clear water to permit normal absorption into the pipe walls provided, however, that after so filling the pipe he shall complete the leakage test within twenty-four hours after filling. When under test, the allowable leakage shall be limited according to the provisions that follow. Specified allowances assume pre-wetted pipe.

Leakage shall be no more than 0.28 gph per inch diameter per 100 feet of sewer, with a hydrostatic head of 6 feet above the crown at the upper end of the test section, or above the natural ground water table at the time of test, whichever is higher. The length of pipe tested shall be limited so that the pressure at the lower end of the Section tested

does not exceed 16 feet of head above the invert, and in no case shall be greater than 700 feet or the distance between manholes when greater than 700 feet.

Where the test head is other than 6 feet, the measured leakage shall not exceed 0.28 gph per inch diameter per 100 feet times the ratio of the square root of the test head to the square root of 6.

$$\text{Leakage maximum} = 0.28 \times \frac{\sqrt{H}}{\sqrt{6}} = 0.114 \quad \sqrt{H}\ \text{gph/inch/100/feet}$$

When the test is to be made one joint at a time, the leakage per joint shall not exceed the computed allowable leakage per length of pipe.

7-17.3(4)C Infiltration Test

Infiltration test leakage shall not exceed 0.16 gph per inch diameter per 100 feet, when the natural ground water head over the pipe is 2 feet or less above the crown of the pipe at the upper end of the test section. The length of pipe tested shall not exceed 700 feet or the distance between manholes when greater than 700 feet.

Where the natural ground water head is more than 2 feet, the measured leakage shall not exceed 0.16 gph per inch diameter per 100 feet times the ratio of the square root of the natural ground water head to the square root of 2.

$$\text{Leakage maximum} = 0.16 \times \frac{\sqrt{H}}{\sqrt{2}} = 0.114 \quad \sqrt{H}\ \text{gph/inch/100/feet}$$

When a suitable head of ground water exists above the crown of the pipe and when the pipe is large enough to work inside, acceptance may be based on the repair of visible leakage by means satisfactory to the Engineer.

7-17.3(4)D Air Pressure Test for Sanitary Sewers Constructed of Air-Permeable Materials

1. Pipelines may be tested with low pressure air by the pressure drop method, in lieu of water infiltration or exfiltration. The pressure drop shall be from 3½ to 2½ psig greater than the average back pressure of ground water above the centerline of the pipe. At the Contractor's option, pipe may be tested without pre-wetting; however, the test allowances herein assume pre-wetted pipe.
2. The allowable rate of air loss shall be .003 cfm per square foot of internal pipe surface, but the total calculated air loss shall be not less than 2 cfm nor more than 3.50 cfm. In the event that the Contractor should elect to test air-permeable pipe without pre-wetting, during dry pipe and dry ground conditions, alternate air loss allowances may be substituted as may be approved by the Engineer, provided it can be demonstrated that the alternate criteria correlates with the standard criteria for wetted pipe.
3. The test equipment to be used shall be furnished by the Contractor and shall be inspected and approved by the Engineer prior to use. The Engineer may at any time require a calibration test of gauges or other instrumentation that is incorporated in the test equipment.
4. Safety Provisions. Plugs used to close the sewer pipe for the air test must be securely braced to prevent the unintentional release of a plug which can become a high velocity projectile. Gauges, air piping manifolds, and valves shall be

located at the top of the ground. No one shall be permitted to enter a manhole where a plugged pipe is under pressure. (Four psig air pressure develops a force against the plug in a 12-inch diameter pipe of approximately 450 pounds) Air testing apparatus shall be equipped with a pressure release device such as a rupture disk or a pressure relief valve designed to relieve pressure in the pipe under test at 6 psi.

5. Pipe under 36 inches in diameter may be tested from manhole to manhole or such shorter lengths determined by the Contractor. Pipe 36 inches in diameter and over shall be tested one joint at a time. Each joint must show no appreciable loss of pressure when held for 30 seconds.

7-17.3(4)E Air Pressure Test for Sanitary Sewers Constructed of Non Air-Permeable Materials

When non air-permeable pipelines are subjected to the low pressure air test, all of the provisions of Section 7-17.3(4)D shall apply except that the pressure drop shall be from 3.5 to 3.0 psig greater than the average back pressure above the center of the pipe, and the minimum time shall be twice that computed as specified under Section 7-17.3(4)D.

7-17.3(4)F Other Test Allowances

All lateral or side sewer branches included in the test Section shall be taken into account in computing allowable leakage. An allowance of 0.2 gallons per hour per foot of head above invert shall be made for each manhole included in a test section.

Upon final acceptance of the work all sewers, side sewers and fittings shall be open, clean, and free draining.

7-17.3(4)G Plugging Existing Sewer Pipe

Where shown in the Plans or where designated by the Engineer, existing sewer pipes shall be plugged on the inlet end with Class 3000 concrete. Care shall be used in placing the concrete in the sewer to see that the opening of the pipe is completely filled and thoroughly plugged.

7-17.3(4)H Deflection Test for Flexible Pipe

Sanitary sewers constructed of flexible pipe shall be tested for deflection not less than 30 days after the trench backfill and compaction has been completed. The test shall be conducted by pulling a properly sized "go-nogo" mandrel through the completed pipeline. Testing shall be conducted on a manhole-to-manhole basis and shall be done after the line has been completely flushed out with water.

The mandrel shall be a rigid, nonadjustable mandrel having an effective length of not less than its normal diameter and an odd-number of legs (9 legs minimum). Minimum diameter at any point along the full length of the mandrel shall be 95 percent of the base inside diameter of the pipe being tested.

Base inside diameter is derived by subtracting a statistical tolerance package from the average inside diameter. The tolerance package is defined as the square root of the sum of squared manufacturing tolerances. The tolerance package for controlled outside diameter pipe consists of (1) outside diameter tolerance specified in applicable ASTM Standard, (2) 12 percent of one wall thickness specified in applicable ASTM Standard, and (3) out of roundness tolerance listed in appendix of applicable ASTM Standard. The items in the tolerance package for controlled inside diameter pipe consists of (1) inside

diameter tolerance listed in appendix of applicable ASTM Standard and (2) out of roundness tolerance listed in appendix of applicable ASTM Standard. When out of roundness tolerance is not listed, use 3 percent of average inside diameter.

The average inside diameter for pipe with controlled outside diameter shall be equal to the average outside diameter as specified in applicable ASTM Standard minus two minimum wall thicknesses as specified in applicable ASTM Standard and minus two times excess wall tolerance of 6 percent. The average inside diameter for pipes with controlled inside diameter shall be the average inside diameter as specified in applicable ASTM Standard.

The Contractor shall be required, at no expense to the Contracting Agency, to locate and uncover any sections failing to pass the test and, if not damaged, reinstall the pipe. The use of a vibratory re-rounding device or any process other than removal or reinstallation shall not be acceptable. The Contractor shall retest the section after replacement of the pipe.

Pipe large enough to work inside of may be accepted on the basis of direct measurement.

7-17.3(4)I Television Inspection

The Engineer may require any or all sanitary sewer lines be inspected by the use of a television camera before final acceptance. The costs incurred in making the initial inspection shall be borne by the owner of the sanitary sewer.

The Contractor shall bear all costs incurred in correcting any deficiencies found during television inspection including the cost of any additional television inspection that may be required by the Engineer to verify the correction of said deficiency.

The Contractor shall be responsible for all costs incurred in any television inspection performed solely for the benefit of the Contractor.

7-17.4 Measurement

The length of sewer pipe will be the number of linear feet of completed installation measured along the invert and will include the length through elbows, tees and fittings. The number of linear feet will be measured from the center of manhole to center of manhole or to the inside face of catch basins and similar type structures.

The concrete Class 3000 for plugging existing sewer pipes will be measured by the cubic yards as specified in Section 7-02.4.

The length of testing sewer pipe in conformance with Section 7-17.3(4) will be the number of linear feet of completed installation actually tested.

Excavation of the sewer trench will be measured the same as structure excavation Class B, by the cubic yard, as specified in Section 2-09.

Shoring or extra excavation trench, will be measured as specified in Section 2-09.4 for shoring or extra excavation Class B.

Measurement of "Bank Run Gravel for Trench Backfill Sewer" will be determined by the cubic yard in place, measured by the neat line dimensions shown in the Plans.

7-17.5 Payment

Payment will be made in accordance with Section 1-04.1, for each of the following bid items that are included in the proposal:

1. "Plain Conc. or V.C. Sewer Pipe ____ In. Diam.", per linear foot.
2. "Cl. ____ Reinf. Conc. Sewer Pipe ____ In. Diam.", per linear foot.
3. "PVC Sewer Pipe ____ In. Diam.", per linear foot.

4. "Ductile Iron Sewer Pipe ____ In. Diam.", per linear foot.
5. "ABS Composite Sewer Pipe ____ In. Diam.", per linear foot.

The unit contract price per linear foot for sewer pipe of the kind and size specified shall be full pay for furnishing, hauling, and assembling in place the completed installation including all wyes, tees, special fittings, joint materials, and adjustment of inverts to manholes for the completion of the installation to the required lines and grades.

6. "Testing Sewer Pipe", per linear foot.

The unit contract price per linear foot for "Testing Sewer Pipe" shall be full pay for all labor, material and equipment required to conduct the leakage tests required in Section 7-17.3(4).

7. "Trench Excavation", per cubic yard.

The unit contract price per cubic yard for "Trench Excavation" shall be full pay for all excavation, removal of water, backfilling, and all other work necessary to the construction of the sewer trench. No separate payment will be made for protection of existing utilities and services. These items shall be considered as incidental to the work of "Trench Excavation" and all costs thereof shall be included in the payment for "Trench Excavation."

8. "Removal and Replacement of Unsuitable Material", per cubic yard.

The unit contract price per cubic yard for "Removal and Replacement of Unsuitable Material" shall be full pay for all work to remove unsuitable material and replace and compact suitable material as specified in Section 7-17.3(1)A.

9. "Bank Run Gravel for Trench Backfill Sewer", per cubic yard.

The unit contract price per cubic yard for "Bank Run Gravel for Trench Backfill Sewer" shall be full pay for all work to furnish, place, and compact material in the trench.

10. "Conc. Class 3000", per cubic yard.

The unit contract price per cubic yard for "Conc. Class 3000" shall be full pay for all work required to plug existing sewer pipes.

11. "Shoring or Extra Excavation Trench", per square foot.

The unit contract price per square foot for "Shoring or Extra Excavation Trench" shall be full pay for the work as specified in Section 2-09.5 for shoring or extra excavation Class B.

8-01.3(10) Inspection

Inspection of any area will be made upon completion of seeding, fertilizing, or mulching. The work in any area will not be measured for payment until a uniform distribution of the materials is accomplished at the specified rate. Areas not receiving a uniform application of seed, fertilizer, or mulch at the specified rate, as determined by the Engineer, shall be reseeded, refertilized, or remulched at the Contractor's expense prior to payment.

8-01.3(11) Mowing

When the proposal contains the bid item "Mowing" or mowing areas are defined, the Contractor shall mow all grass growing areas and slopes 2½ to 1 or flatter except for naturally wooded and undergrowth areas. Trimming around traffic facilities, structures, planting areas, or other features extending above ground shall be accomplished preceding or simultaneously with each mowing by use of power-driven or hand-operated machinery and tools to achieve a neat and uniform appearance.

Each mowing shall be considered as one coverage of all grass areas to be mowed within a defined area. Prospective bidders shall verify the estimated acreage for mowing as shown in the Plans, the topography, irregularity of the area, slopes involved, and access limitations to determine the appropriate equipment to use. Equipment and tools shall be provided such as, but not limited to, tractor-operated rotary or flail-type grass cutting machines and tools or other approved equipment. Power driven equipment shall not cause ruts or deformation of improved areas. Sickle type grass cutters will be permitted only on slopes of drainage ditches, berms, or other rough areas. The equipment and tools shall be in good repair at all times and maintained so that a clean, sharp cut of the grass will result at all times. The actual number of mowings will be as determined by the Engineer. The height of mowing will be 4 to 6 inches or as designated in the Plans or in the Special Provisions.

Mowing equipment shall be operated in such a manner and equipped with suitable guards as to avoid throwing rocks or debris onto the traveled way or off the right of way. Equipment which pulls or rips the grass or damages the turf in any manner will not be permitted. The Engineer will be the sole judge of the adequacy of the equipment, safeguards, and methods of use. The Contractor will not be required to collect or remove clippings from the project except on the traveled way, shoulder, walkway, or other improved areas.

8-01.4 Measurement

Measurement for topsoil, Type A, Type B, and Type C, will be by the cubic yard in the haul conveyance at the point of delivery.

The quantity of excavation taken from roadway excavation, borrow, strippings, or other excavation item to be utilized as topsoil Type B will not be deducted from the pay quantities of the respective items. If haul is to be paid on the excavated item from which topsoil Type B material is taken, no deduction will be made in the mass diagram for the quantity so taken. The topsoil Type B material will be considered as having been hauled into the general distribution of the excavated material.

The area of seeding, fertilizing, liming, mulching, and soil binder or tacking agent to be paid for will be by ground slope measurement in acres of actual seeding, fertilizing, liming, mulching, and applying soil binder or tacking agent completed and accepted in accordance with these Specifications and as shown in the Plans.

APPENDIX D

CONCRETE REPAIR PRODUCTS

CONCRESIVE® 2070

LVP Acrylic Crack Filler

10/3/96
No longer manufacture this product
per mike At Master Builders - Seattle
767-7777
MGD

DESCRIPTION:

A low vapor pressure (LVP), low viscosity, high molecular weight (HMWM), acrylic monomer designed primarily to reconsolidate, fill and seal cracked concrete substrates.

RECOMMENDED FOR:

- Gravity filling of cracks on bridge and parking garage decks.

FEATURES/BENEFITS:

- Ultra low viscosity
- Superior penetration in topical applications

ESTIMATING:

Concresive® 2070 is packaged in 5 and 50 U.S. gallon (19 and 189 liter) units.

Coverage Rates - 100 to 150 ft²/gallon (2.5 to 3.7 m²/liter) depending on the volume of cracks and the porosity of the concrete.

MATERIAL PROPERTIES[1]:

Form	Ultra low viscosity liquid
Color	Clear light amber

Pot Life, 100 g mass	45 min	
Thin Film Cure Time, hr		
Bulk	1-2 hrs	
Surface	5-7 hrs	
Viscosity, cps (ASTM D 2393)		18
Density, lb/gal (ASTM D 1475)		8.9
Vapor Pressure, mm/Hg (ASTM D 323)		<1
Flash Point (ASTM D 3278)		>200°F (>93°C)
Volatile Content (ASTM D 3269)		25%
Tg (DSC Onset) (ASTM D 3418)		90°F (32°C)
Bond Strength to Concrete (ASTM C 882)		>1,500psi >10.3MPa

APPLICATION:

Surface Preparation Procedures

Concrete surfaces to which the CONCRESIVE 2070 is to be applied must be dry and free of dust, dirt, oil, wax, curing compounds, efflorescence, laitance and all other bond breaking materials. The recommended method of preparation is shot or grit blasting.

Mixing

Conversion of the CONCRESIVE 2070 from the liquid to the solid state requires the use of a promoter/initiator system. The cobalt naphthenate promoter and the cumene hydroperoxide initiator are packaged in pre-measured kits which accompany each unit of product shipped. When mixing CONCRESIVE 2070 in less than full unit batches, use the formula provided below to determine the correct volume of promoter and initiator required for the batch size selected.

The mixing sequence is as follows:

1. Add cobalt naphthenate to the CONCRESIVE 2070 monomer and mix thoroughly.
2. Add cumene hydroperoxide to the blend prepared in Step 1. Mix thoroughly.

WARNING. NEVER MIX COBALT NAPHTHENATE WITH CUMENE HYDROPEROXIDE. BOTH PRODUCTS TOGETHER WILL REACT EXPLOSIVELY.

Small batches of CONCRESIVE 2070 may be measured and mixed by volume. The recommended formula is:

Batch Size	Cobalt Naphthenate	Cumene Hydroperoxide
1 gallon	40 ml	160 ml
5 gallons	200 ml	800 ml

Instructions for measuring cobalt naphthenate and cumene hydroperoxide:

1. Using a 400 ml polypropylene beaker, measure the required amount of cobalt naphthenate promoter as shown in the table above. Add the cobalt naphthenate to the CONCRESIVE 2070 monomer and mix thoroughly.
2. To preclude a violent reaction, the 400 ml beaker used to measure the cumene hydroperoxide must be completely free of any cobalt residue. Measure the required amount of cumene hydroperoxide as shown in the table above, and add this to the promoted CONCRESIVE 2070. Mix thoroughly.

[1]The properties listed on this data sheet are typical and descriptive. Test and cure temperature of 77°F (25°C).

Master Builders Technologies

Large batch sizes of CONCRESIVE 2070 are more conveniently proportioned by weight. The recommended formula is:

Parts by Weight
CONCRESIVE 2070 - 100.0
Cobalt naphthenate promoter - 1.0
Cumene hydroperoxide initiator - 4.0

Placing
Begin application within 10 minutes following addition of the cumene hydroperoxide. Flood the area to be treated with promoted and initiated CONCRESIVE 2070 at a rate of 100-150 ft^2/gal (2.5 to 3.7 m^2/liter). Allow the material to penetrate for approximately 10 minutes. Remove or redistribute excess material with brooms or squeegees. Broadcast dry, bagged #12 mesh sand onto the treated surface at a rate of 0.25 - 0.30 lb/yd^2. Allow the material to reach a tack free degree of cure before opening to traffic.

CLEAN UP:

Clean mixing equipment and application tools as soon and as often as practical with a suitable solvent such as acetone or MEK (both flammable), or 1,1,1, trichloroethane or methylene chloride (both non-flammable).

LIMITATIONS:

- Application Temperature Range (substrate) 50°F to 120°F (10°C to 49°C).
- Minimum Cure Temperature 50°F (10°C).

(The polymerization of high molecular weight monomers is subject to oxygen inhibition, i.e., material exposed to air is slow to cure. Material applied in a film thickness of approximately 5 mils or less is extremely susceptible to this phenomenon. In the absence of elevated substrate temperatures and/or direct sunlight,thin films may require in excess of 72 hours to become tack free. Consequently, applications of this product on cool substrates, at night or in shaded areas should be undertaken only after careful consideration of temperature and sunlight factors, and probable time required to overcome the oxygen inhibition effect. Do not open treated areas to traffic until the surface is tack-free.)

- Shelf life of CONCRESIVE 2070 is 18 months in original, unopened container. The container must not be exposed to direct sunlight. Maximum storage temperature is 80°(27°C).

SAFETY:

Any hazard associated with the use of this product can be significantly reduced by observing all precautions which are found on the product data sheet, Material Safety Data Sheets (MSDS) and product labels. Please read this literature carefully before using this product.

This product may be irritating to the skin and eyes and may have lacrimatory (tear causing) effects. Use of barrier creams, protective clothing, solvent resistant gloves and boots and eye goggles is recommended. Concentrated vapors may cause dizziness and/or nausea. Provide adequate ventilation in indoor or confined outdoor areas.

NIOSH (National Institute of Occupational Safety and Health) recently reported observations of some adverse effects to workers exposed to air levels of cobalt at or below the current permissible OSHA limit. However, the trace amount of cobalt salt present in the promoted product is not expected to be a concern.

Health and safety materials and equipment appropriate to the application of CONCRESIVE 2070 should be available prior to use of this product.

For additional information, contact your local Master Builders representative.

Flammability
CONCRESIVE 2070 contains an acrylic monomer which is combustible (flash point [SFCC] > 200°F) and considered to have low flammability under normal ambient conditions.

WARRANTY:

Master Builders stands behind its products when used by competent persons in accordance with current, published recommendations but cannot be held responsible for difficulty caused by other materials or conditions or by inferior workmanship. Master Builders reserves the right to have the true cause of any difficulty determined by accepted test methods.

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Master Builders Technologies

Master Builders Technologies
Specialty Products
Data Sheet 7D50

Printed in U.S.A. 1/92

Renderoc SD2

(formerly Renderoc SD)

Polymer modified cementitious repair compound for repairs over 1/8" thick

USES

Renderoc SD2 is designed specifically for deep horizontal repairs and the resurfacing of concrete where the depth of repair is greater than 1/8 inch. It is for use on bridges, walkways, parking structures and industrial applications.

ADVANTAGES

- **Thermal compatibility** - coefficient of thermal expansion similar to normal concrete
- Shrinkage-compensated
- Designed for resurfacing of large areas
- **High build** - may be used at thicknesses to 2 inches without additional aggregate, or over 2 inches with addition of aggregate.
- **High structural strength** - achieves 6,500 to 7,000 psi @ 28 days.
- **High bond strength** - polymer modification ensures excellent adhesion.
- **Waterproof** - special additives ensure optimum density and water repellency to cured surface.
- **Freeze-thaw resistant** - reduced permeability results in increased freeze-thaw resistance.

DESCRIPTION

Renderoc SD2 is a two-component polymer modified cementitious patching compound. It was designed specifically for resurfacing and leveling concrete surfaces where the repair is greater than 1/8 inch in thickness. It contains shrinkage compensating additives which allow it to be used at thicknesses to 2 inches without the addition of aggregate. For greater thicknesses, the addition of aggregate is recommended. Incorporation of the **Renderoc Liquid** ensures that **Renderoc SD2** will be more waterproof, freeze-thaw resistant and provide better adhesion than standard portland cement mortars. Its coefficient of thermal expansion is similar to that of normal concrete.

Technical support

Fosroc offers a comprehensive range of high performance, high quality construction products. In addition, **Fosroc** offers a technical support service to specifiers and contractors, as well as on-site assistance in locations worldwide. In the US, dial 1-800-645-3954.

Design criteria

Renderoc SD2 may be applied in thicknesses ranging from 1/8 inch to 2 inches. For greater thicknesses, the addition of aggregate is recommended. With allowance for control and expansion joints, **Renderoc SD2** may be placed over large surface areas.

PROPERTIES

Compressive Strength, psi ASTM C-109	3,000 @ 1 day 7,000 @ 28 days
Flexural Strength, psi ASTM C-348	1,500
Slant Sheer Bond, psi AASHTO T-237	1,400
Water Absorption, %Absorbed ASTM C-140	0.90[A]
Water Vapor Transmission Rate, Perms, ASTM E-96	4.6[B]
Water Repellency After 35 Freeze-thaw cycles ASTM C-67	No change in Water absorption
Freeze Thaw resistance, % weight change NYS DOT 216 @ 50 cycles	1.2[B]
Density, lbs./cu. ft.	137
Coefficient of thermal Expansion, per °C	7.3×10^{-6} (Compatible with concrete)
Setting time, hrs	2-4
Expansion ASTM C-157	0.000

Pot life approximately 45 minutes.

A. Water absorption for conventional mortar is 6-8%.

B. Water vapor transmission rate for conventional mortar is 20-30 perms.

C. Conventional mortar has weight loss of 10-20%.

All application and performance values are typical for the material but may vary because of variations in test methods, conditions, configurations.

APPLICATION INSTRUCTIONS

Surface preparation

Concrete substrate must be structurally sound. Loose or unsound concrete should be hammered out. Clean the surface by removing any dust, unsound or contaminated material, plaster, oil, paint, grease, corrosion deposits or algae. Where breaking out is not required, roughen the surface and remove any laitance by light scabbling or sandblasting.

Oil and grease deposits should be removed by steam cleaning, detergent scrubbing or the use of a degreaser. To ensure optimum repair results, the effectiveness of decontamination should be assessed by a pull-off test.

Expose fully any corroded steel in the repair area to 100% of its circumference and remove all loose scale or corrosion deposits. Steel should be cleaned to a bright condition paying particular attention to the back of exposed steel bars. Sandblasting is recommended for this process.

Where corrosion has occurred due to the presence of chlorides, the steel should be high-pressure washed with clean water immediately after sandblasting to remove corrosion deposits from pits and imperfections in the steel surface.

Priming of reinforcing steel

Apply one full coat of **Nitoprime Zincrich** and allow to dry before continuing. If any doubt exists about having achieved an unbroken coating, a second application should be made and, again, allowed to dry before continuing.

Priming of substrate

The substrate should be saturated surface dry (SSD = thoroughly soaked with clean water and any excess removed). All surfaces should be primed with a slurry consisting of 2 parts by volume of **Renderoc SD2** powder mixed into 1 part by volume of Renderoc Liquid. Using a stiff mason's brush, the slurry should be scrubbed into the substrate and the repair mortar should be installed as soon as the slurry becomes tacky and before it dries.

In exceptional circumstances, e.g. where a substrate/repair barrier is required or where the substrate is wet or likely to remain permanently damp, **Nitobond Epoxy Gel 400** bonding compound should be used in place of the cementitious slurry. Contact your local **Fosroc** office for further information.

Mixing

Care should be taken to ensure that **Renderoc SD2** is thoroughly mixed. A forced action mixer is essential. Mixing in a suitably sized drum using an approved spiral paddle and a slow speed (400-500 rpm) heavy duty drill is acceptable for the occasional one-bag mix. Free-fall mixers should not be used and mixing of partial bags should not be attempted. The material should always be mixed in a clean container.

For normal applications, place 3/4 of a gallon jug (2.84 liters) of **Renderoc Liquid** into the clean mixer, and with the machine in operation, add 1 complete 55 pound (25 kg) bag of **Renderoc SD2** and mix for 3 minutes until fully homogeneous. Avoid over mixing. Note that the powder should always to added to the liquid. Dependent on the ambient temperature and the desired consistency, additional **Renderoc Liquid** may be added up to a maximum liquid content of 1 gallon (3.79 liters) per 55 pounds (25 kg) bag of **Renderoc SD2.**

Application

Exposed steel reinforcing bars should be firmly secured to avoid movement during the application process as this will effect mortar compaction, build and bond. While the slurry is still damp, apply **Renderoc SD2** by trowel or screed. When applying mortar to the substrate, ensure good compaction of the mortar into the slurry by tamping or trowelling on both horizontal and vertical surfaces. This may be more consistently achieved by compacting a layer of material into the repair area before completely filling the void.

For areas in excess of 2 inches in thickness, 14 lbs. of 3/8" pea gravel per bag (25% extension) must be added. In areas over 4 inches in thickness, 28 lbs. of 3.8" pea gravel per bag (50% extension) must be added. The addition of aggregate may require additional **Renderoc Liquid.**

Low temperature conditions

In cold applications down to 45°F (7°C), maintaining the **Renderoc Liquid** at 80°F (26°C) is advisable to accelerate strength development. Normal precautions for winter working with cementitious materials should then be adopted. The material should not be applied when the substrate and/or air temperature is 45°F (7°C) and falling. At 45°F (7°C) static temperature or at 45°F (7°C) and rising, the application may proceed. Do not apply if the temperature is expected to fall below 45°F (7°C) within 24 hours of application.

High temperature conditions

At ambient temperatures above 80°F (26°C), the materials should be stored in the shade. It is also advisable to keep mixing and application equipment cool. Shade the work area or carry out application during non-sunlight hours after the substrate has cooled. Mix material for a minimum period of time, enough to ensure good dispersion of the powder component in the liquid (approximately 2-3 minutes). Overmixing may cause excessive air entrapment. Take extra precaution to ensure that the slurry does not dry out prior to placement of the repair mortar.

Immediately upon finishing, spray a thin layer of **Renderoc Liquid** over the repaired surface. Immediately cover with Burlene. The burlap side should be water saturated. The Burlene should be applied with the plastic side toward the patch. Ensure that all edges of Burlene are firmly held down to avoid air movement between the Burlene plastic and the surface of the repair.

Leave the Burlene in place for a minimum of 5 days. During this period, wetting of the burlap will help to keep the repair cool. Any movement of the repaired area should be avoided during this period.

Finishing

When desired thickness is achieved, finish smooth with a wood or sponge float. A broom can be used for a rough finish. An extra tight, smooth surface can be achieved by wetting the surface slightly using a steel trowel. However, this may cause a variation in color.

Curing

Renderoc SD2 is a cement-based repair mortar. Proper curing is extremely important and **Renderoc SD2** should be cured immediately after finishing in accordance with good concrete practice (ACI 308) to approach peak performance of the repair. Proper curing is of particular importance when ambient conditions may cause rapid moisture loss (high temperature, low humidity, or moderate to high winds). The use of **Nitobond Acrylic**, sprayed on to the surface of the finished repair in a continuous film, is recommended. Large areas of greater than 5 sq. ft. (0.47 sq. m), should be cured as trowelling progresses without waiting for completion of the entire area. Other curing options include a fine mist of water; application of wet burlap (burlap must be kept continuously moist); application of polyethylene sheeting taped down at the edges; or a combination of the above to keep the finished repair moist for a minimum of 7 days. In cold conditions, the finished repair must be protected from freezing. If doubts arise concerning proper curing procedures, consult the local **Fosroc** office.

Clean-up
Renderoc SD2 should be removed from tools, equipment and mixers with clean water immediately after use. Cured material can only be removed mechanically.
Equipment used for application of **Nitoprime Zincrich** and **Nitobond Epoxy Gel 400** should be cleaned with **Fosroc Solvent 102**.
Clean hands and skin immediately with soap and water or industrial hand cleaner. Do not use solvents.

LIMITATIONS
Renderoc SD2 should not be used when the temperature is below 45°F (7°C) and falling. Do not mix partial bags. **Renderoc SD2** should not be exposed to rain or moving water during application. If any doubts arise concerning temperature or substrate conditions, consult the local **Fosroc** office.

Estimating
Supply

Renderoc SD2	No. 1 Kit = 55 lbs powder, 1 gal liquid No. 2 Kit = 275 lbs powder, 5 gal liquid
Nitoprime Zincrich	1 gallon, 1 quart, 1 pint cans
Nitobond Epoxy Gel 400	2 gallon kit

Coverage and yield

Renderoc SD2	No. 1 Kit yields 0.5 cubic feet No. 2 Kit yields 2.5 cubic feet
Nitoprime Zincrich	268 square feet/gallon 67 square feet/quart 32 square feet/pint
Nitobond Epoxy Gel 400	100 square feet/gallon

Note: The actual yield per bag of **Renderoc SD2** will depend on the consistency used. The coverage figures for liquid products are theoretical. Due to waste factors and the variety and nature of possible substrates, practical coverage figures will be reduced.

Storage
All products have a shelf life of 12 months if kept in recommended storage conditions in the original, unopened containers with the exception of **Nitoprime Zincrich**, which has a shelf life of 3 months.

Storage conditions
Store in cool, dry conditions in the original, unopened bags or cans. If stored at high temperatures and/or high humidity conditions, the shelf life may be reduced to 4 to 6 months. **Renderoc Liquid** should be protected from freezing.

Health and safety
Avoid breathing dust and avoid contact with skin. Rubber gloves and/or barrier creams, protective clothing and goggles should be worn. Provide sufficient mechanical and/or local exhaust ventilation t maintain a low level of dust exposure. If ventilation is not provided. a NIOSH/MESA respirator should be worn.

Flash points
Flash point above 200°F.

Disposal
In case of spillage, absorb liquid and clean up powder by use of dustless method and dispose of in accordance with applicable local state and federal regulations.

Special precautions
Since emptied containers retain product residues (vapor, liquid, and/or solid), extreme caution should still be exercised in their handling.
For industrial use only.
Keep out of reach of children.
Not for internal consumption.
Prior to use, consult MSDS and read warning noted on product package for more information.

Additional information
Fosroc manufactures a wide range of products specifically designec for the repair and restoration of damaged reinforced concrete. This includes hand-placed and spray-applied repair mortars, fluid micro-concretes, chemical resistent epoxy mortars, and a comprehensive system of protective coatings. In addition, a wide range of complimentary products is available, including joint sealant waterproofing membranes, concrete stains, grouts, flooring specialties and materials for repair and protection of concrete in water/wastewater treatment. There are also specific **Fosroc** Division addressing the Precast Concrete and Mining industries.
Several educational training videos and technical papers are available, which provide more detail about the mechanisms which cause corrosion within reinforced concrete structures and the solutions which are available to arrest or retard these destructive forces. Further information is available from the publication "Concre Repair and Protection -- The Systematic Approach", available in seven language formats.
For further information about products, educational seminars, trainin videos or publications, contact the local **Fosroc** office.

Fosroc Inc.

55 Skyline Drive
Plainview, NY 11803
Tel 800-645-3954
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665 North County Road 101
Woodland, CA 95776
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WARRANTY

Fosroc Inc., warrants its products to be free of defects in material and workmanship for a period of one (1) year from the date of manufacture. Under this warranty, Fosroc will provide, at no charge, product in containers to replace any product proved to be defective when applied in accordance with Fosroc written instructions and in applications recommended by Fosroc as to be suitable for this product. Fosroc's obligation hereunder shall be limited solely to such replacement and shall be conditioned upon receipt by Fosroc of written notice of any alleged defects promptly after discovery thereof within the warranty period. Absence of such claims in writing during this period will constitute a waiver of all claims with respect to such product. This Warranty does not include discoloration or change in the visual appearance of the product due to the accumulation of or streaking of dirt or other airborne materials deposited on the surface from the atmosphere. Fosroc does not warrant the color fastness of any product unless specifically stated otherwise. The foregoing is the exclusive remedy of the buyer and THERE ARE NO OTHER WARRANTIES BY FOSROC OF ANY NATURE WHATSOEVER, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Fosroc shall not be liable for damages of any sort, including remote or consequential damages, resulting from any claimed breach of any warranty, whether express or implied, including any warranty of merchantability or fitness for a particular purpose or from any other cause whatsoever.

Nitoseal 230

A coal-tar modified polyurethane sealant, caulking and expansion joint compound

USES

For sealing horizontal movement joints in building and civil engineering construction above or below ground. For highways, bridges, airport runways, driveways, subways, and sewage treatment plants. Suitable for areas subject to fuel and chemical spillage.

ADVANTAGES

- Excellent elastomeric and recovery properties
- Prolonged life due to high weathering resistance
- Good resistance to chemicals and hydrocarbon fuels
- Wide range of operating temperatures

DESCRIPTION

Nitoseal 230 is a two-component coal-tar modified polyurethane sealant specifically designed for sealing exterior horizontal joints. It is applied as a black, flowable sealant which cures to an elastomeric, water-tight compound.

Joint Design

The width of the joint should be 5 times the expected movement. For joints in concrete that are 1/2" or less in width, **Nitoseal 230** should be poured 1/2" deep. In all other joints, the depth of the sealant should be 50% of the width. (It must never exceed 100% of the width).

Joint Backing

A closed cell polyethylene should be used to fill and control depth of joint as required. It should be slightly larger than the width of the joint to insure optimum performance, and must be installed after priming. It also functions as a bond breaker not allowing adhesion to the bottom of the joint. If it is not used, a polyethylene film should be placed between the sealant and the bottom of the joint.

APPLICATION INSTRUCTIONS

Application

Surfaces should be clean, dry, and free from oil, dirt, grease, rust, laitance, etc. The base and catalyst must be completely mixed mechanically (slow speed drill, 80 to 100 rpms, with slotted paddle). Once mixed, it can be poured in horizontal joints. Solvents such as lacquer thinner, toluene, ketones, or **Fosroc Solvent 102** can be used to clean equipment, before material has cured.

Priming

For optimum results, all surfaces to be sealed should be primed with **Nitoseal 230** Primer, a clear, two component epoxy.

Color

Black

PHYSICAL PROPERTIES

Hardness, Shore A	25-35
Tensile Strength, psi	60-80
Ultimate Elongation, %	250-400
Modulus (100% Elongation),psi	15-20
Recovery after 100% Elongation, %	85-90
Pot Life @75°F, min.	45
Application Temperature Range	+40°F to 100°F
Serviceable Temperature Range	-40°F to 200°F
Temperature Resistance	Continuous 180°F Non-Continuous 200°F
Tack Free Time, Hrs.	14-18
Ultimate Cure, Days	5

CHEMICAL RESISTANCE

Nitoseal 230 has excellent resistance to intermittent attack from the following compounds:

Jet Fuel	Aliphatic Solvents
Gasoline	Alcohol
Mild Acids	Water
Mild Alkali	Oil and Greases

SPECIFICATION COMPLIANCE

Nitoseal 230 meets federal specification SS-S-200 (Runway Sealant) and SS-S-170 (Highway and Bridge Sealant).

PACKAGING AND COVERAGE

Nitoseal 230 is available in 2 gallon and 10 gallon kits.
1 gallon covers approximately 231 cu. in.

FOSROC

Fosroc Inc.

55 Skyline Drive
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APPENDIX E

GEOSYNTHETIC REPAIR PRODUCTS

GUNDLE 60 mil Textured HDPE
(HDT 60)

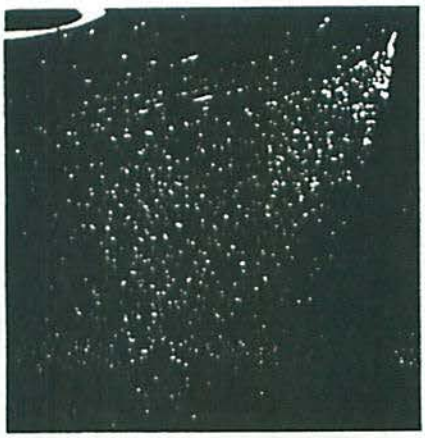
Gundle Lining Systems Inc

Gundle®

Textured Gundline® HDT Maximizes Slope Stability

Gundle Lining Systems has developed a method for adding a rough texture to the surface of our durable High Density Polyethylene (HDPE) liners. The result is a high performance product called Gundline HDT which increases slope stability in engineered landfills and other lining applications.

Gundline HDT's special textured surface dramatically improves slope stability by increasing friction between the synthetic liner and soils, geotextiles, and other geosynthetics. Cover soils are held on the liner with the greatly increased friction, and safety-conscious engineers can improve factors of safety on slopes of varying steepness. Table 1 lists the improvements in friction angle for Gundline HDT, determined by direct shear box testing.



The innovative friction surface of Gundline HDT is manufactured simultaneously with extrusion of the solid barrier portion of the liner as opposed to being added after extrusion. It's a rough surface, fully integrated with the sheet during the molten phase of manufacture. As a result, it has excellent abrasion resistance and remains intact regardless of chemicals contacting the sheet surface.

TABLE I: DIRECT SHEAR BOX FRICTION ANGLES*

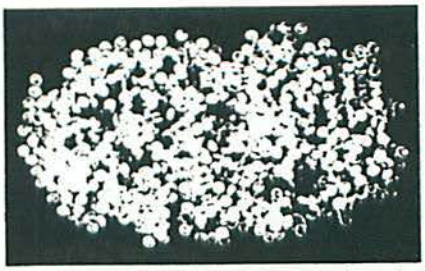
SLIDING SURFACE	*FRICTION ANGLE (DEGREES) POLYETHYLENE*	*TEXTURED*
Gundline/H.R. Clay	16	24
Gundline/Ottawa Sand	17	26
Gundline/Geotextile (Nonwoven)	11	29

*Note: Friction angles for the products listed are typical only and may vary with local soil conditions. Accordingly, engineers must test friction angles for the product using site specific soil composition for all designs incorporating the product.

Gundline HDT Retains The Important Advantages Of Gundline® HD.

Manufactured in 22.5 foot wide seamless rolls and in thicknesses ranging from 40-100 mils of barrier wall, Gundline HDT features the same important qualities that have made Gundline HD the world's leading lining system. Tensile strength before yielding, biaxial elongation, tear resistance, puncture resistance, ultraviolet light resistance, chemical resistance, dimensional stability, heat resistance, and stress crack resistance are all excellent. So is resistance to microorganisms and rodent damage.

As with Gundline HD, Gundle manufactures Gundline HDT with only the top performing pipe grade HDPE resin. The superior high grade resin creates an ideal structure to the finished sheet.



HDPE resin and carbon black used in manufacturing.

Gundline® VLT

Gundline VLT combines the exceptional elongation and elastic properties of Gundline® VL (Very Low Density Polyethylene Liner) with the outstanding friction characteristics and slope stabilizing qualities of Gundline® HDT! The combination makes the liner ideal for landfill closures and other applications where elongation, flexibility, and slope stability are important. The excellent multi-axial elongation of Gundline VLT accommodates differential settlement while the textured surface provides long term slope stability.

Gundline HDT Provides Solutions To Difficult Applications.

A recent problem at Islip, New York illustrates the effectiveness of Gundline HDT. It began when the city's municipal landfill neared capacity. The problem was then compounded by the lack of available land for expansion. But Gundle provided the solution. After considering all available options, it was decided to expand vertically—a process dubbed "piggybacking." A new cell would be created to sit atop the existing closed and capped landfill. However, it was critical to establish slope stability for the new, steep slopes of this 80-foot high addition. So Gundle manufactured and installed 1.2 million square feet of Gundline HDT and successfully increased the friction angle between the liner and the sand over sixty percent.

Today, not only does Islip have 1.8 million cubic yards of new refuse disposal capacity, but they also have peace of mind knowing it's lined with the industry's most stable and durable liner.

GUNDLINE® HDT/VLT SPECIFICATIONS

TYPICAL PROPERTIES	TEST METHOD	GUNDLINE® HDT GAUGE (NOMINAL)					GUNDLINE® VLT GAUGE (NOMINAL)			
		30 mil	40 mil	60 mil	80 mil	100 mil	30 mil	40 mil	60 mil	80 mil
Density (g/cc)	ASTM D1505	.94 Min	.94 Min	.94 Min	.94 Min	.94 Min	.910 -.925	.910 -.925	.910 -.925	.910 -.925
Melt Flow Index (Max.) (190 C, 2.16 kg, g/10 minutes)	ASTM D1238 Condition E	.3	.3	.3	.3	.3	.6	.6	.6	.6
Carbon Black (%)	ASTM D1603	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Tensile Properties	ASTM D638 Modified Type IV Dumb bell @ 2 ipm									
Strength at Yield (PPI)		70	95	140	190	240	NA	NA	NA	NA
Strength at Break (PPI)		30	50	75	100	125	56	84	112	169
Elongation at Yield (%)		13	13	13	13	13	NA	NA	NA	NA
Elongation at Break (%)		150	150	150	150	150	400	400	400	400
Multi Axial Elongation at Break (%, Min.)	GRI-GM4	15	15	15	15	15	75	75	75	75
Tear Resistance (Pounds)	ASTM D1004 Die C	22	30	45	60	75	12	18	27	36
Puncture Resistance (Pounds)	FTMS 101 Method 2065	30	52	80	105	130	51	64	75	85
Environmental Stress Crack (Hours, Min.)	ASTM D1693 10% Igepal, 50°C	1500	1500	1500	1500	1500	1500	1500	1500	1500
Dimensional Stability (% Change)	ASTM D1204	+/-2	+/-2	+/-2	+/-2	+/-2	+/-2	+/-2	+/-2	+/-2
Thermal Stability OIT (Minutes)	ASTM D3895 130°C, 800 PSI 0_2	2000	2000	2000	2000	2000	2000	2000	2000	2000
Low Temperature Brittleness (°F)	ASTM D746 Procedure B	-112	-112	-112	-112	-112	-112	-112	-112	-112
Coefficient of Linear Thermal Expansion (x 10 $^{-4}$/cm/cm°C)	ASTM D696	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Water Vapor Transmission (g/m^2/day Max.)	ASTM E96	.1	.1	.1	.1	.1	.1	.1	.1	.1

Note: All values, except when specified as minimum or maximum, are typical test results.

SUPPLY SPECIFICATIONS

The following describes typical roll dimensions for Gundline HDT and VLT.

NOMINAL THICKNESS		WIDTH		LENGTH		AREA	
mil	mm	ft.	m	ft.	m	ft. 2	m2
30	0.75	22.5	6.86	625	190	14,063	1306
40	1.0	22.5	6.86	600	183	13,500	1254
60	1.5	22.5	6.86	420	128	9,450	878
80	2.0	22.5	6.86	320	97	7,200	669
100*	2.5	22.5	6.86	250	76	5,625	522

* 100 mil is only available in HDT

GUNDLINE HDT and GUNDLINE VLT are rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Custom lengths available upon request.

Gundle Lining Systems Inc

Gundle®

"If it needs lining, it needs Gundle."
19103 Gundle Road
Houston, Texas 77073 U.S.A.
Phone: (713) 443-8564
Toll Free: (800) 435-2008
Telex: 166657 GundleHou
Fax: (713) 875-6010

These specifications are to be used only as a general guideline for use by engineers in formulating preliminary specifications, and should not be relied upon absent site-specific product testing; and Gundle assumes no responsibility for the improper reliance upon or misuse of such data. In addition, product design and specifications are subject to change without notice.

TREVIRA 011/550 Non-woven Geotextile

Whatever your geotextile application, you can't specify a better engineering fabric than Trevira® Spunbond.

TREVIRA
SPUNBOND

Trevira® Spunbond nonwoven engineering products are highly needled fabrics with excellent tensile properties, high filtration potential and outstanding permeability.

Trevira® Spunbond Type 11 products are 100% continuous filament polyester nonwoven needlepunched engineering fabrics. They deliver a combination of advantages unmatched by any other spunbonded geotextiles. They're resistant to freeze-thaw, soil chemicals and ultraviolet light exposure.

Trevira® Spunbond nonwoven engineering fabrics offer excellent performance where the requirement is tensile reinforcement, planar flow, filtration, or separation. They are ideal for roadways, railbeds, drainage systems, lining systems, retaining walls. And much more.

TYPICAL PHYSICAL PROPERTIES OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	011/120	011/140	011/200	011/250	011/280	011/350	011/420	011/450	011/550
Fabric Weight	oz/yd²	ASTM D-5261	3.5	4.2	6.0	7.5	8.5	10.5	12.4	13.5	16.5
Fabric Thickness, t	mils	ASTM D-5199	60	70	90	110	120	140	165	170	210
Grab Strength (MD/CD)[1]	lbs	ASTM D-4632	120/105	150/125	230/180	300/235	320/260	420/350	475/400	540/450	650/570
Grab Elongation (MD/CD)[1]	%	ASTM D-4632	75/85	75/85	75/85	75/80	75/80	75/80	75/80	80/80	85/85
Trapezoid Tear Strength (MD/CD)[1]	lbs	ASTM D-4533	50/40	55/50	80/75	105/95	110/100	140/125	170/145	180/165	225/200
Puncture Resistance	lbs	ASTM D-4833	55	65	95	115	125	155	170	185	225
Mullen Burst Strength	psi	ASTM D-3786	195	225	330	400	435	560	600	700	855
Water Flow Rate	gpm/ft²	ASTM D-4491	195	190	170	150	130	120	105	100	80
Permittivity, Ψ	sec⁻¹	ASTM D-4491	2.61	2.54	2.27	2.01	1.76	1.6	1.47	1.34	1.07
Permeability, k = Ψxt	cm/sec	ASTM D-4491	.40	.45	.52	.56	.53	.57	.62	.58	.57
AOS	Sieve Size mm	ASTM D-4751	70-100 .210-.149	70-100 .210-.149	70-100 .210-.149	70-100 .210-.149	70-120 .210-.125	100-120 .149-.125	100-140 .149-.106	120-140 .125-.106	140-170 .106-.088
Standard Roll Widths[2]	ft		12.5 and 15.0								
Standard Roll Lengths[2]	ft		400	400	300	300	300	300	300	300	300

[1]MD = Machine Direction, CD = Cross Machine Direction.

[2]Other width and length rolls are available upon request.

MINIMUM† PHYSICAL PROPERTIES OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	011/120	011/140	011/200	011/250	011/280	011/350	011/420	011/450	011/550
Fabric Weight	oz/yd²	ASTM D-5261	3.3	4.0	5.7	7.1	8.0	10.0	12.0	13.0	16.0
Fabric Thickness, t	mils	ASTM D-5199	50	55	75	95	105	125	145	150	185
Grab Strength	lbs	ASTM D-4632	90	110	160	210	230	305	350	390	500
Grab Elongation	%	ASTM D-4632	60	60	60	60	60	60	60	65	70
Trapezoid Tear Strength	lbs	ASTM D-4533	30	40	60	75	80	100	120	130	150
Puncture Resistance	lbs	ASTM D-4833	45	50	80	95	100	130	150	155	195
Mullen Burst Strength	psi	ASTM D-3786	170	190	285	360	380	510	550	640	780
Water Flow Rate	gpm/ft²	ASTM D-4491	155	150	130	110	90	80	65	60	40
Permittivity, Ψ	sec⁻¹	ASTM D-4491	2.07	2.01	1.74	1.47	1.20	1.07	0.87	0.80	0.53
Permeability, k = Ψxt	cm/sec	ASTM D-4491	.26	.28	.33	.35	.32	.34	.32	.31	.25
AOS	Sieve Size mm	ASTM D-4751	50 .300	50 .300	70 .210	70 .210	70 .210	70 .210	70 .210	100 .149	100 .149

†These minimum values represent minimum test values as determined from Quality Control (Q.C.) testing.

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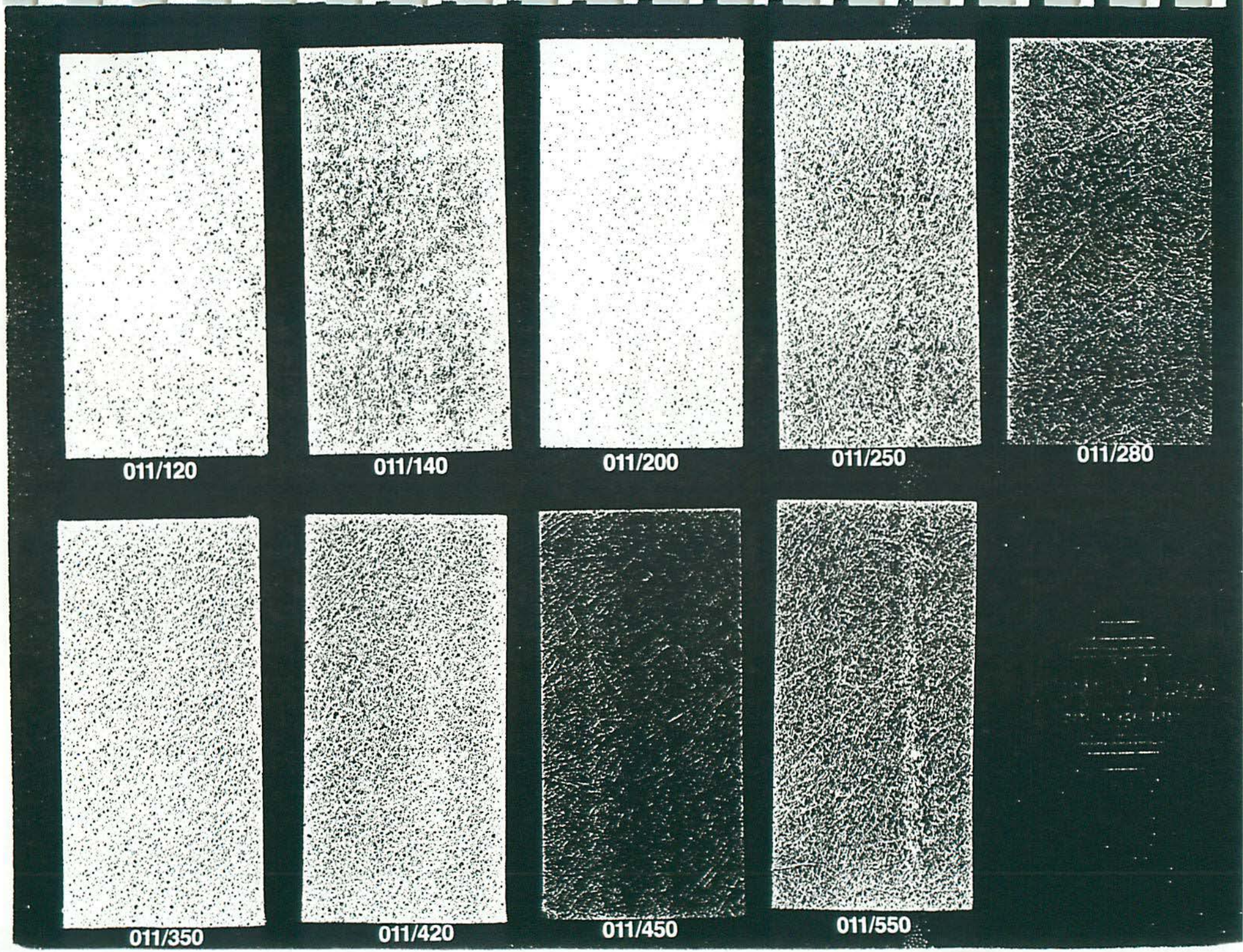
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) U.S.A.

Hoechst Celanese

Hoechst

BENTOFIX Geosynthetic Clay Liner

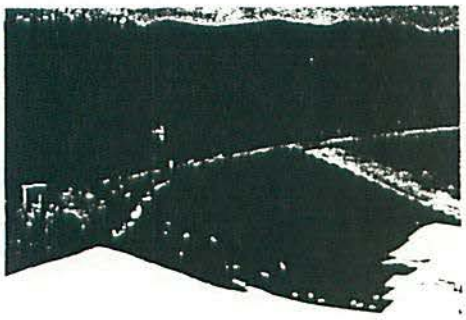
FSI

Bentofix™
GEOSYNTHETIC CLAY LINERS

Bentofix™ GEOSYNTHETIC CLAY LINERS

Needlepunching gives shear strength.

Applications:

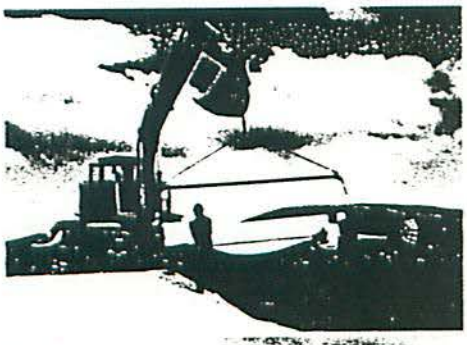


Composite linings

Bentofix GCLs reduce the thickness of, or even replace, multi-lift compacted clay layers called for in composite landfill liners or cap systems.

Secondary containment

Bentofix GCLs are used as secondary containment barriers in aboveground tank farms or around underground storage tanks.



Liquid containment and conveyance

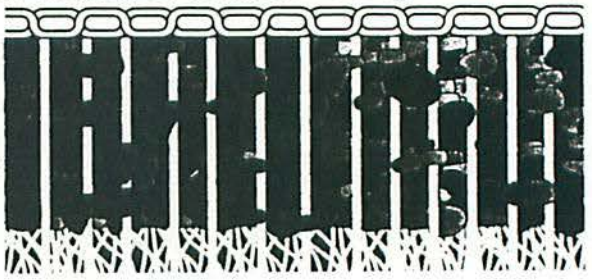
Used by themselves, Bentofix GCLs provide exceptional liquid containment in reservoirs, irrigation canals, and industrial ponds and lagoons.

Bentofix™ Geosynthetic Clay Liners (GCLs) are high-strength, needlepunched bentonite composites which combine high-quality geotextile outer layers with an inner layer of low-permeability sodium bentonite clay.

Bentonite is a natural sealant which actuates on contact with water-based liquids. Upon hydration, the bentonite in Bentofix GCLs swells to form a low-permeability clay layer with a hydraulic conductivity less than 1×10^{-9} cm/sec. As a result, Bentofix provides the same hydraulic protection as several feet of compacted clay.

Combining low permeability, chemical resistance, and internal shear strength with rugged durability, Bentofix GCLs provide an effective barrier to the flow of liquids. Simple, cost-effective installation makes Bentofix a viable alternative for a wide range of applications, including composite landfill linings, landfill caps, secondary containment for storage tanks, stormwater and wastewater retention, canals, dams and reservoirs.

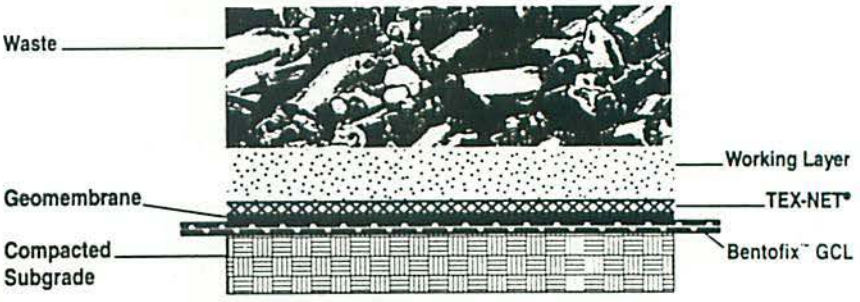
Cross Section of Bentofix Geosynthetic Clay Liner



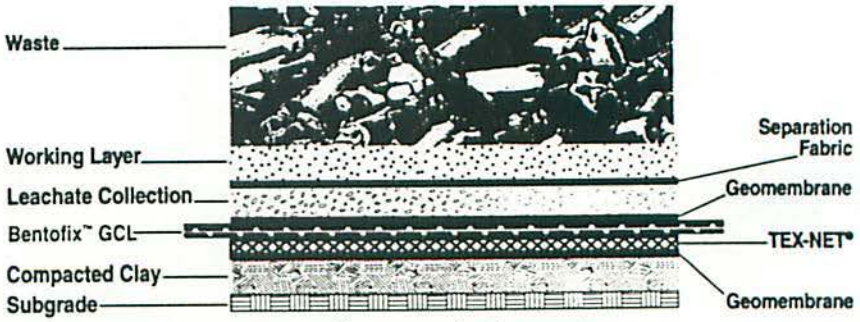
Increase your airspace and your liner efficiency.

In a composite landfill liner system, Bentofix GCLs can reduce, and in some cases replace, the thick compacted clay layers normally required. This can mean reduced excavation or increased containment volume. And in a landfill, increased airspace means increased revenues.

Typical Liner System Cross-Sections Using Bentofix GCL



Single-composite liner system



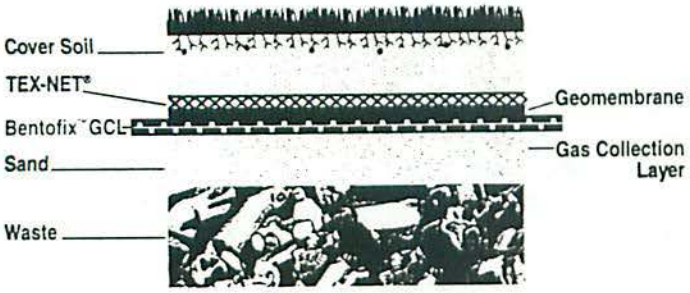
Double-composite liner system

High quality, natural sodium bentonite provides leak protection.

Bentofix GCLs are part of an important trend toward the combined use of geosynthetics and geologic materials in containment applications. In a typical composite liner system, GCLs work together with polyethylene geomembranes to increase liner system efficiency.

Caps and closures

Bentofix GCLs are ideally suited for use in caps and landfill closures. Used alone, or in conjunction with a geomembrane, Bentofix GCLs act as an excellent barrier to infiltrating rainwater.



Landfill composite cap

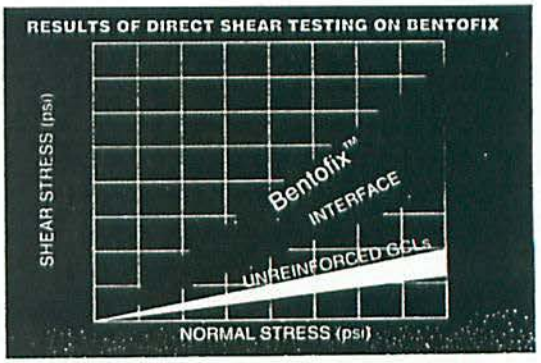
Needlepunching provides important advantages.

By needlepunching fibers from the non-woven geotextile layer through the sodium bentonite layer and into the opposite geotextile layer, a completely uniform GCL is produced — with important advantages that apply to any application.

High internal shear resistance.

Needlepunching reinforces the otherwise weak layer of bentonite clay. Unreinforced bentonite is susceptible to failure even on gradual slopes, since the hydrated clay has little or no shear strength. The Bentofix needlepunching process consistently reinforces the bentonite layer with hundreds of tensile fibers that resist shear and transfer the stresses into our sturdy geotextiles.

With Bentofix, the GCL is no longer the limiting factor on side slopes. You can use Bentofix to replace cumbersome compacted clay layers on steep side slopes and be assured of slope stability.*



Bentofix's internal friction angle is higher than the interface friction angles typically found elsewhere in a multi-layer lining system.*

Consistent bentonite content

Needlepunching prevents lateral migration of the bentonite within Bentofix — in either the dry or hydrated state. As a result, a consistent bentonite content is preserved throughout the composite.

Simplified installation

During installation, the needlepunched fibers hold the bentonite in place. This means that Bentofix is more durable and has a greater bearing capacity, once hydrated, than conventional GCLs. This can greatly reduce the adverse effects of premature hydration during the installation process.

No delamination

The mechanical bonding and inherent confining stress resulting from needlepunching prevents separation of the geotextiles during installation and after the bentonite hydrates. This increased confining stress also improves the hydraulic properties of Bentofix GCLs under low normal loads.

Assured quality control

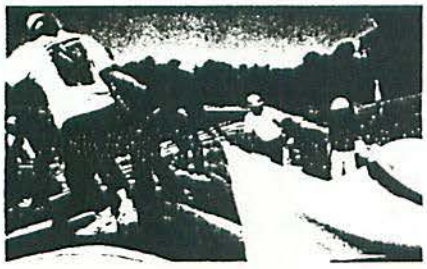
Since Bentofix GCLs are a manufactured product, we can perform detailed quality control at the manufacturing facility. To ensure the quality of our Bentofix GCLs, we subject them to multiple strength and permeability tests. As a result, expensive and time-consuming on-site quality control testing — like that required for compacted clay liners — can be reduced.

Because Bentofix GCLs are manufactured from only high-quality raw materials, we can ensure consistent properties and eliminate the chance of time-consuming and costly on-site rejection.

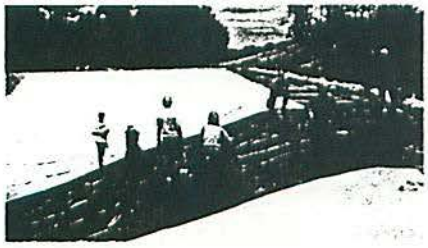
*In all applications, design-specific parameters will determine actual values, and site-specific testing should be carried out to determine the shear angle in each application.

Bentofix GCLs are easy to install

Bentofix GCLs are supplied in rolls 15 feet wide with standard lengths of 100 feet. We can custom-manufacture longer rolls that may be required for special projects. Bentofix GCLs are packed in clearly marked plastic covers to ensure that they are kept dry. Our unique wrapping system allows the rolls to be unloaded easily and stored in their protective sleeves.



1) To install, just suspend a roll of Bentofix from a spreader bar at the top of the slope and unroll, or secure the free end in an anchor trench and back the suspended roll down the slope. Seams on slopes should be perpendicular to the slope whenever possible.

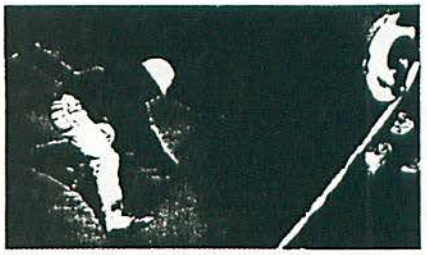


2) In applications where geomembranes are placed over the Bentofix GCL and higher normal loads are expected, a simple overlap is all that is required. A clearly marked matchline on each panel edge indicates the correct overlap. Overlaps should be shingled in the direction of water flow.

3) In applications with low normal loads which use Bentofix as the primary lining material, bentonite may be used to augment the seal at the overlap. While deploying the bentonite, it is easy to check that the overlap is free of folds and foreign objects.

Place a 3"-4"-wide continuous strip of bentonite on top of the unrolled mat, between the edge of the roll and the matchline. Apply the bentonite at an approximate rate of 1/4 pound per lineal foot. Install the next panel so that its edge covers the bentonite and lines up with the matchline.

4) No special equipment is required — only a carpet knife or an electric cutter is needed to cut Bentofix GCLs to any configuration necessary.



5) GCLs must be properly confined by a minimum soil cover before being allowed to hydrate. Although Bentofix is not as susceptible to water damage as some other bentonite composites, some simple guidelines will help you avoid costly delays. Our experienced staff will be glad to assist you in determining the most suitable method of deployment.

Call Fluid Systems at (800) 346-9107 for more details on how Bentofix Geosynthetic Clay Liners can provide you with better hydraulic properties, greater shear strength, simpler installation, greater durability and increased airspace.

FSI

FLUID SYSTEMS

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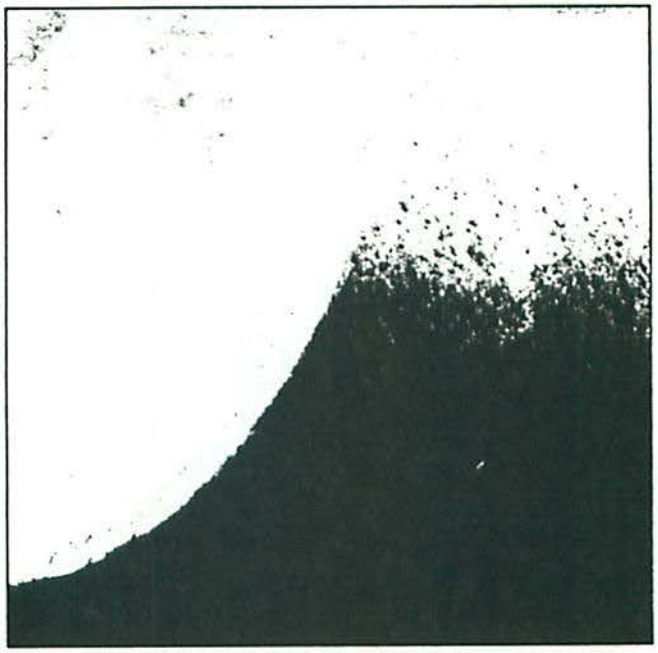
76-5/93-3M

FLUID SYSTEMS

RECOMMENDED SPECIFICATIONS



Bentofix™ GEOSYNTHETIC CLAY LINER

Bentofix™ GEOSYNTHETIC CLAY LINER
Recommended Specifications

1.0 These specifications describe Bentofix Geosynthetic Clay Liner (GCL), a bentonite geotextile composite that is needlepunched to provide high shear resistance and durability. The supply and installation of these materials shall be in strict accordance with these specifications and contract drawings.

2.0 Description

2.01 The top and bottom layers of the GCL shall be geotextiles. At least one layer will be a nonwoven needlepunched geotextile.

2.02 The primary constituent of the GCL shall be a natural sodium montmorillonite clay, called bentonite, placed on the carrier layer geotextile at a minimum rate of 1 lb/sf.

2.03 The nonwoven geotextile shall be needle punched through the bentonite into the carrier geotextile, effectively attaching the top geotextile to the bottom geotextile, encapsulating the bentonite.

3.0 Manufacturer Quality Assurance/Quality Control

3.01 Each geotextile layer shall be Quality Control tested during the manufacturing process to ensure they meet material specifications. The geotextile manufacturer shall perform the following tests at least once every 60,000 square feet (ft^2), and certify conformance with the following:

mass per unit area	trapezoid tear strength
thickness	burst strength
tensile strength	

3.02 The bentonite shall be tested at a frequency correlating to one test per 50,000 square feet (ft^2) of finished GCL, to ensure conformance with:

moisture content	fluid loss
water absorption capacity	montmorillonite content (methylene blue test)
swell index	

3.03 Additionally, the bentonite producer will provide certifications for the following properties:

moisture content	montmorrillonite content (XRD test)
water absorption	fluid loss
bulk density	

3.04 The GCL finished product will be tested at a frequency of one test every 3,000 sf for:

overall thickness	mass per unit area

every 10,000 ft^2 for:

moisture content	grab tensile strength
peel strength	puncture strength

and every 100,000 ft^2 for:

hydraulic conductivity

3.05 The GCL shall be continually bonded and reinforced by needle-punching.

3.06 No separation of geotextile components shall occur if the liner is cut, punctured, torn or hydrated.

3.07 The roll shall be marked with a continuous "match line" at each edge to ensure that the minimum recommended overlap is maintained during installation.

3.08 The GCL shall pass over bright back-lighting prior to roll-up so that consistency of the bentonite layer within the GCL can be visually inspected.

3.09 Needle detecting devices and magnets will scan the entire width of the roll prior to roll-up to ensure no broken needles are present in the final product.

3.10 The GCL shall be Bentofix™ supplied by Fluid Systems, Cincinnati, Ohio or approved equal.

3.11 The GCL shall conform to the following specifications.

PROPERTY	TEST	STANDARD	UNITS	*VALUE*
Physical				
-Mass Per Unit Area	ASTM D3776	typical	lb/ft² (g/m²)	1.10 (5390)
-Thickness	ASTM D1777	typical	in (mm)	0.24 (6.0)
-Moisture Content	ASTM D4643	maximum	%	10
Mechanical				
-Grab Tensile[1]	ASTM D4632	typical	lb (N)	120 (530)
-Puncture	ASTM D4833	typical	lb (N)	170 (750)
-Friction Angle[2]	ASTM D5321	typical	degrees	25
-Peel Strength	ASTM D4632	typical	lb (N)	5 (22)
Hydraulic				
-Water Permeability[3]	GRI GCL-2	maximum	cm/s	1×10^{-9}
COMPONENT	**TEST**	**STANDARD**	**UNITS**	***VALUE***
Carrier Geotextile				woven
-Mass Per Unit Area	ASTM D3776	minimum	oz/yd² (g/m²)	3.25 (110)
Cover Geotextile				nonwoven
-Mass Per Unit Area	ASTM D3776	minimum	oz/yd² (g/m²)	7.25 (250)
Sodium Bentonite				
-Mass Per Unit Area		minimum	lb/ft² (g/m²)	1.0 (4900)
-Montmorillonite	XRD-Method	minimum	%	90
Content	Methylene-Blue	minimum	%	70
-Moisture Content	ASTM D4643	maximum	%	10
-Swell Index	USP NF XVII	minimum	ml	25
-Water Absorption	Enslin-Neff	minimum	%	600
DIMENSION		**STANDARD**	**UNITS**	***VALUE***
-Width × Length[4]		nominal	ft (m)	15.2 × 100 (4.6 × 30.5)
-Area per Roll		minimum	ft² (m²)	1520 (140)
-Packaged Weight		typical	lb (kg)	1740 (790)

NOTES:
[1]Typical tensile values given for weakest principle direction.
[2]Samples hydrated under an initial normal stress of 7.5 psi (50 kPa) and sheared internally.
[3]Water permeability values given correspond to effective stress of 10 psi (67 kPa).
[4]Nominal roll dimensions exclusive of protective edge area.

4.0 Manufacturers Statement

4.01 The manufacturer shall submit, upon request, certificates indicating that the material meets the above specification, supported by accompanying quality control test results.

4.02 The GCL shall be supplied in rolls, clearly labeled with the following information:

Manufacturer's Name	Typical Roll Weight
Product Name	Typical Roll Dimensions
Roll Number	Lot Number

5.0 Shipping, Handling and Storage

5.01 The GCL shall be wrapped in plastic to protect it from ultraviolet light and to ensure the product stays dry during shipment and prior to use.

5.02 The GCL material shall be shipped and stored by appropriate means so that no damage is caused to the material. Material shall be stored in a secure area to protect against standing water, precipitation, contamination, theft, and vandalism.

5.03 Rolls shall be lifted by inserting a steel bar, capable of supporting the full weight of the roll, through the center core.

6.0 Installation

6.01 The Earthwork Contractor shall be responsible for preparing and maintaining the subgrade and anchor trenches in a condition suitable for the laying of the GCL.

6.02 The method and equipment used to deploy the GCL shall not damage the adjacent geosynthetics or the supporting subgrade surface.

6.03 Adequate temporary loading such as sandbags or tires shall be provided to prevent GCL uplift due to strong winds.

6.04 All wrinkles shall be pulled out and overlaps shall be free of obstructions, debris and rocks.

6.05 Seams shall be a simple overlap unless the expected normal load that will be applied to the liner and the intended function determine the need for the addition of granular bentonite.

6.06 Overlap seams shall be placed so that the edge of the upper panel aligns with the matchline on the lower panel.

6.07 The GCL shall be secured in an anchor trench at the top of the slope as per the contract drawings.

6.08 Material will be deployed from the high elevation to the low elevation to protect against the adverse effect of precipitation during deployment. Panels shall be shingled in a down slope direction.

6.09 All seams shall be parallel with the direction of the slope. Horizontal seams shall not be allowed on slopes unless approved by the engineer.

6.10 In general, the GCL installation shall halt during any form of precipitation and exposed GCL shall be covered in a timely manner.

6.11 Only as much of the GCL should be deployed in a given day as can be covered during that day either by a geomembrane or confining soil layer.

6.12 Repairs will be made by placing a patch of the same material over the damaged area extending at least one foot (12 inches) beyond the damaged area in every direction.

7.0 Specific Applications

7.01 Additional details may be required for specific applications. Contact Fluid Systems for more detailed information.

FLUID SYSTEMS

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0010-5/93-5M

TENSAR DC4205
Geocomposite

DRAINAGE COMPOSITE DC4205

The drainage composite shall consist of a geotextile bonded to each side of a drainage net. The drainage composite shall have a low compressibility in order to maintain high flow capacity over a wide range of confining pressures. The bonding process shall not introduce adhesives or other foreign products. The strength of the bond between the drainage net and the geotextile shall be greater than the friction developed between the geotextile and a soil. The drainage composite shall maintain a high flow under long term loading conditions and shall be resistant to all forms of biological or chemical degradation normally encountered in a soil environment. The drainage composite shall be made from the drainage net and geotextile products whose property requirements are listed below.

PROPERTY	TEST METHOD	NOTES	UNITS	VALUE
Flow Capacity	ASTM 4716	1		
• Gradient of 1				
• Transmissivity @ 500 psf			$x10^{-3}ft^2/sec$	21
			(gpm/ft width)	(9.55)
• Transmissivity @ 10,000 psf			$x10^{-3}ft^2/sec$	16
			(gpm/ft width)	(7.24)
• Transmissivity @ 20,000 psf			$x10^{-3}ft^2/sec$	8.6
			(gpm/ft width)	(3.86)
Mechanical Properties		3,4,5		
• Compression		1,2		
@ 20,000 psf			%	50
• Peak Tensile Strength-MD	ASTM D5035	6	lbs/ft	575
Drainage Net				
• Aperture Size	I.D. Calipered	7	inches	0.3
• Thickness	O.D. Calipered	8,9	inches	0.20
• Polyethylene Polymer				
-Specific Gravity	ASTM D792		g/cm^3	0.940
-Carbon Black Stabilization	ASTM D4218		%	2.5
Geotextile		10		
• Grab Tensile Strength	ASTM D4632		lbs	130/110
• AOS	ASTM D4751		US Std.Sv.Sz.	70
• Weight	ASTM D1910		oz/sy	4.0,4.5,6.0,8.0,10
Composite				
• Laminate Bond Strength	ASTM F904	11	g/in	400
• Dimensions - Finished Product				
-Thickness	O.D. Calipered		in	0.24
-Roll Length			ft	225
-Roll Width (Drainage Net)			ft	14
• Roll Weight			lbs	890

Notes

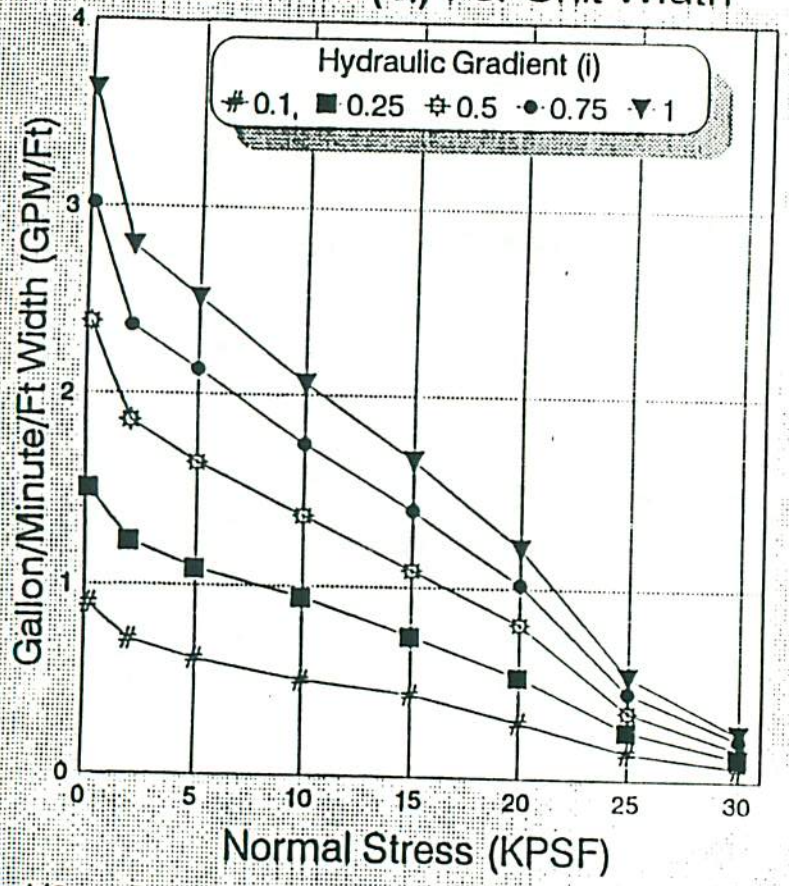
1. Test values are for the core net only.
2. Compression Tests are performed on a 2-inch square sample loaded at a 1mm/minute constant rate of strain.
3. Test values are for drainage net prior to bonding process.
4. All test values are nominal, unless otherwise indicated.
5. MD - Machine (roll) Direction.
6. Minimum value.
7. Inside dimensions in each principal direction are measured by calipers.
8. Outside dimensions in each principal direction are measured by calipers.
9. Thickness is measured by placing the specimen flat on a comparator base and lowering a round 1/2 inch diameter flat end contact surface squarely over a junction.
10. Geotextile splices within each roll of finished goods shall be considered acceptable product. The splicing methods shall include, but are not limited to, stitching or heat bonding. The finished splice shall maintain the continuity of the filtration function of the geotextile. These methods will be considered viable and acceptable unless otherwise specified.
11. Minimum value of a random 5 sample (MD) average between the polyethylene geonet and the needle punched geotextile.

The Tensar Corporation
1210 Citizens Parkway
Morrow, GA 30260
1-800-845-4453

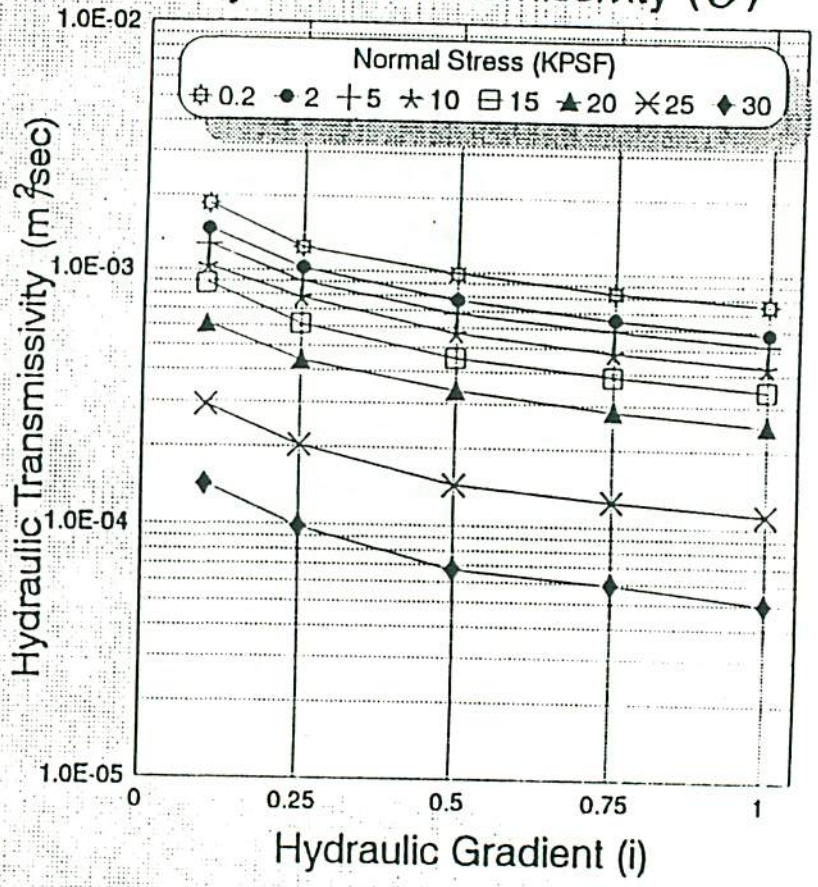
TRANSMISSIVITY & FLOW PERFORMANCE CURVES

DC4205*

Flow Rate (Q) Per Unit Width



Hydraulic Transmissivity (θ)



*(6 oz. Polyester Geotextile) Trevira 1120
Boundary Conditions:Plate/Sample/Plate
Typical Test Results
TTC414C

October 9,1992

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1210 Citizens Parkway
Morrow, Georgia 30260
(404) 968-3255

THE TENSAR CORPORATION

TRANSMISSIVITY TEST RESULTS

COMPOSITE SCORE 226

TTC Test No: 414

Product: DC4205-60

Rig No: 5

Lot no: 920829

Date Tested: 9/10/92

Technician: J Welte

Test Duration: Short Term

Boundary Conditions: metal plate/Sample/metal plate

Load (psf)	Gradient (i)	Net Water (gal)	Average E.T. Min. (1/1000)	Water Temp. (Deg. C))	Sample Width (meter)	FLOW (Q) per Unit Width GPM/FT	TRANSMISSIVITY GPM/FT	M2/Sec (x10EE-4)	Ft2/Sec (x10EE-3)
200	0.10	1.90	2.125	22.5	0.286	0.90	8.96	18.58	20.00
200	0.25	1.90	1.272	22.5	0.286	1.50	6.00	12.42	13.36
200	0.50	1.90	0.801	22.5	0.286	2.38	4.76	9.86	10.61
200	0.75	1.90	0.632	22.5	0.286	3.02	4.02	8.33	8.97
200	1.00	1.90	0.526	22.5	0.286	3.63	3.63	7.51	8.08
500	0.10	1.90	2.379	23.0	0.286	0.79	7.92	16.40	17.66
500	0.25	1.90	1.375	23.0	0.286	1.37	5.48	11.35	12.22
500	0.50	1.90	0.901	23.0	0.286	2.09	4.18	8.66	9.32
500	0.75	1.90	0.715	23.0	0.286	2.64	3.52	7.28	7.83
500	1.00	1.90	0.598	23.0	0.286	3.15	3.15	6.53	7.02
1,000	0.10	1.90	2.539	23.0	0.286	0.74	7.43	15.37	16.54
1,000	0.25	1.90	1.439	23.0	0.286	1.31	5.24	10.85	11.68
1,000	0.50	1.90	0.936	23.0	0.286	2.01	4.03	8.34	8.98
1,000	0.75	1.90	0.736	23.0	0.286	2.55	3.41	7.05	7.59
1,000	1.00	1.90	0.627	23.0	0.286	3.01	3.01	6.22	6.70
2,000	0.10	1.90	2.632	23.5	0.286	0.71	7.08	14.66	15.78
2,000	0.25	1.90	1.511	23.5	0.286	1.23	4.93	10.21	10.99
2,000	0.50	1.90	1.002	23.5	0.286	1.86	3.72	7.70	8.29
2,000	0.75	1.90	0.791	23.5	0.286	2.36	3.14	6.50	7.00
2,000	1.00	1.90	0.669	23.5	0.286	2.79	2.79	5.77	6.21
5,000	0.10	1.90	3.082	23.0	0.286	0.61	6.12	12.66	13.63
5,000	0.25	1.90	1.726	23.0	0.286	1.09	4.37	9.04	9.73
5,000	0.50	1.90	1.150	23.0	0.286	1.64	3.28	6.79	7.31
5,000	0.75	1.90	0.887	23.0	0.286	2.13	2.83	5.87	6.31
5,000	1.00	1.90	0.750	23.0	0.286	2.51	2.51	5.20	5.60
10,000	0.10	1.90	3.729	23.5	0.286	0.50	5.00	10.34	11.13
10,000	0.25	1.90	1.980	23.5	0.286	0.94	3.76	7.79	8.39
10,000	0.50	1.90	1.363	23.5	0.286	1.37	2.73	5.66	6.09
10,000	0.75	1.90	1.073	23.5	0.286	1.74	2.32	4.79	5.16
10,000	1.00	1.90	0.906	23.5	0.286	2.06	2.06	4.26	4.58
15,000	0.10	1.90	4.359	23.5	0.286	0.43	4.28	8.85	9.53
15,000	0.25	1.90	2.528	23.5	0.286	0.74	2.95	6.10	6.57
15,000	0.50	1.90	1.705	23.5	0.286	1.09	2.19	4.52	4.87
15,000	0.75	1.90	1.331	23.5	0.286	1.40	1.87	3.86	4.16
15,000	1.00	1.90	1.120	23.5	0.286	1.66	1.66	3.44	3.71
20,000	0.10	1.90	6.264	24.0	0.286	0.29	2.94	6.09	6.55
20,000	0.25	1.90	3.481	24.0	0.286	0.53	2.12	4.38	4.72
20,000	0.50	1.90	2.264	24.0	0.286	0.81	1.63	3.37	3.63
20,000	0.75	1.90	1.808	24.0	0.286	1.02	1.36	2.82	3.03
20,000	1.00	1.90	1.523	24.0	0.286	1.21	1.21	2.50	2.70
25,000	0.10	1.90	13.429	23.0	0.286	0.14	1.40	2.91	3.13
25,000	0.25	1.90	7.678	23.0	0.286	0.25	0.98	2.03	2.19
25,000	0.50	1.90	5.425	23.0	0.286	0.35	0.70	1.44	1.55
25,000	0.75	1.90	4.163	23.0	0.286	0.45	0.60	1.25	1.35
25,000	1.00	1.90	3.471	23.0	0.286	0.54	0.54	1.12	1.21
30,000	0.10	1.90	28.910	23.5	0.286	0.07	0.69	1.43	1.54
30,000	0.25	1.90	15.745	23.5	0.286	0.12	0.47	0.96	1.05
30,000	0.50	1.90	11.530	23.5	0.286	0.16	0.32	0.67	0.72
30,000	0.75	1.90	8.787	23.5	0.286	0.21	0.28	0.59	0.63
30,000	1.00	1.90	7.697	23.5	0.286	0.24	0.24	0.50	0.54

All flow and transmissivity values corrected to 20 degrees C.

The Tensar Corporation

1210 Citizens Parkway
Morrow, Georgia 30260
(404) 968-3255

GUNDLE LINING CONSTRUCTION COMPANY

TACOMA HISTORICAL COAL

DC4205006225
NS1405 GEONET DATA

LOT NUMBER=5-0142

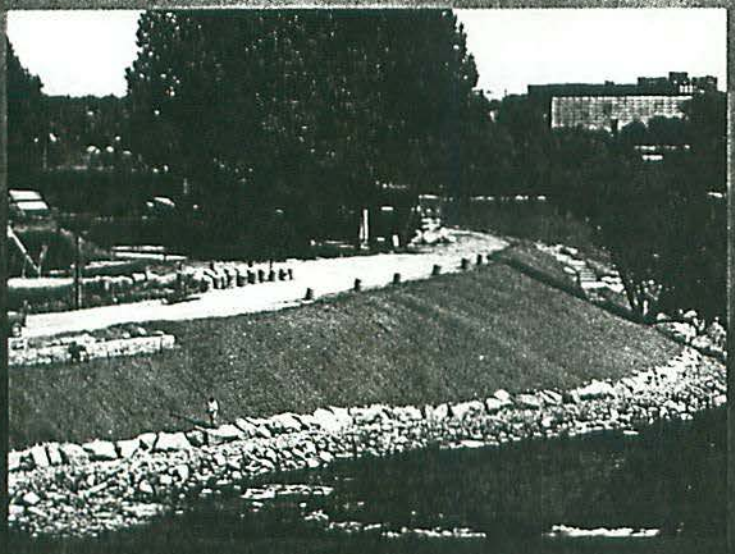
ROLL NUMBER	THICKNESS (mm)	TENSILE STRENGTH (lb/ft)	% CB
33	5.85	775.9	2.26
39	5.88	777.2	2.33
45	5.80	740.9	2.25
51	5.77	727.2	2.32
57	5.87	706.6	2.35
63	5.78	720.3	2.39
69	5.95	747.7	2.32

APPENDIX F

TURF REPAIR PRODUCTS

NORTH AMERICAN GREEN®

Erosion control has never been more advanced



NORTH
AMERICAN
GREEN®

14649 Highway 41 North • Evansville, Indiana 47711

1-812-867-6632 1-800-772-2040 in USA 1-800-448-2040 in Canada 1-812-867-0247 FAX

member
International Erosion
Control Association

member
Erosion Control Technology Council

North American Green® Straw/Coconut Fiber Erosion Control Blankets

Developed for severe slopes, medium flow channels, and applications requiring extended protection during vegetation establishment. The North American Green straw/coconut fiber blanket consists of heavy-weight, UV stabilized netting and a uniform straw matrix supplemented with durable coconut fiber for long lasting, high performance erosion control.

SC150

The SC150 blanket features a 70% straw, 30% coconut fiber matrix sewn between a heavy-weight UV stabilized top net and a lightweight bottom net. The heavy duty, long lasting net and coconut fiber supplement make the SC150 an effective erosion solution on 2:1 - 1:1 slopes, medium-discharge channels, and areas requiring blanket protection for more than one growing season.

SC150 Specifications

Material Composition

Straw	.35 lbs/sq yd (.19 kg/sq m)
Coconut	.15 lbs/sq yd (.08 kg/sq m)
Net	heavyweight UV stabilized top, lightweight bottom
Thread	cotton, bio-degradable

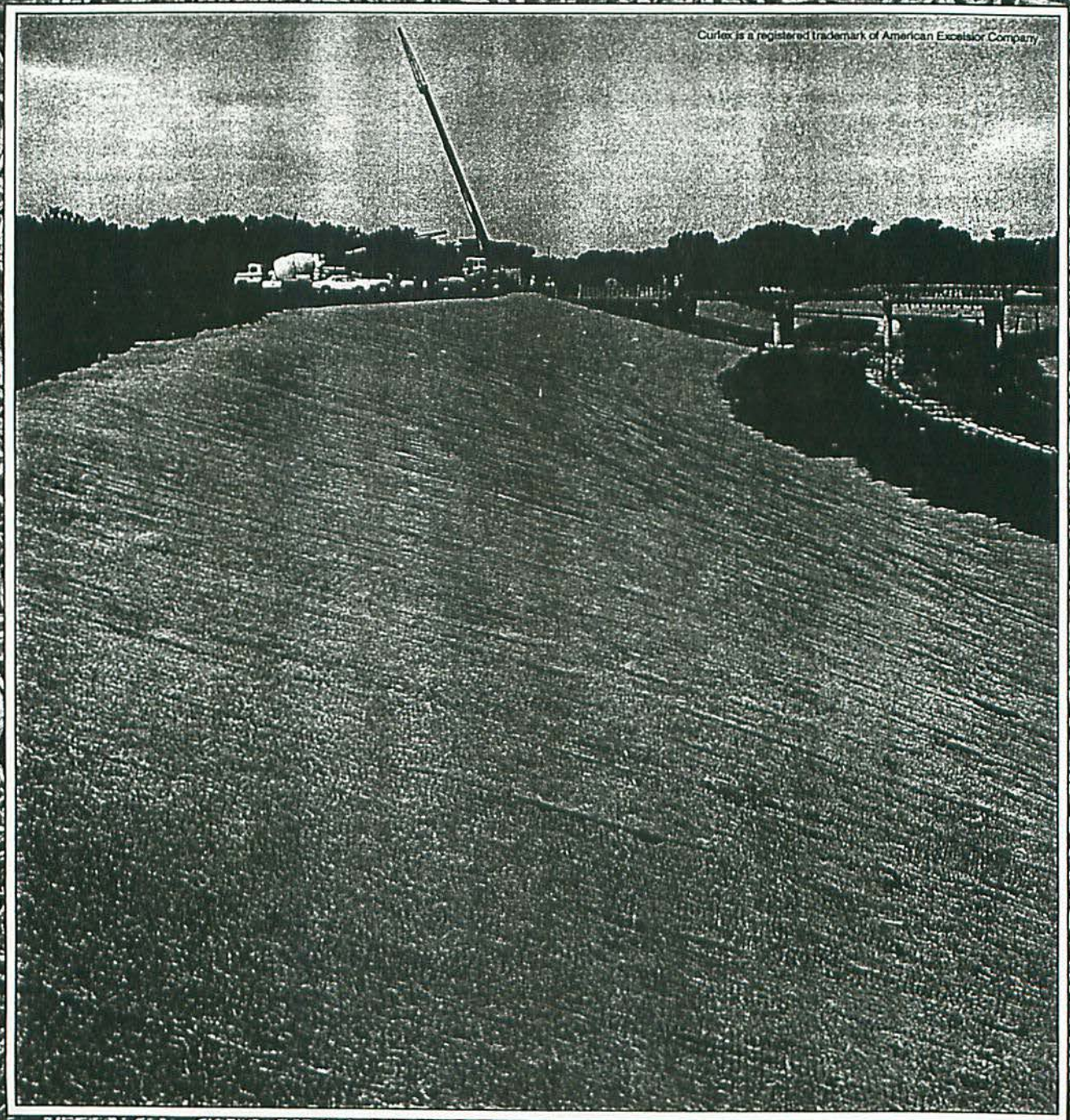
SC150 Roll Specifications

Width	6.5 ft (2 m)
Length	83.5 ft (25.5 m)
Weight	30 lbs (13.6 kg)
Area	60 sq yd (51 sq m)

American Excelsior Company

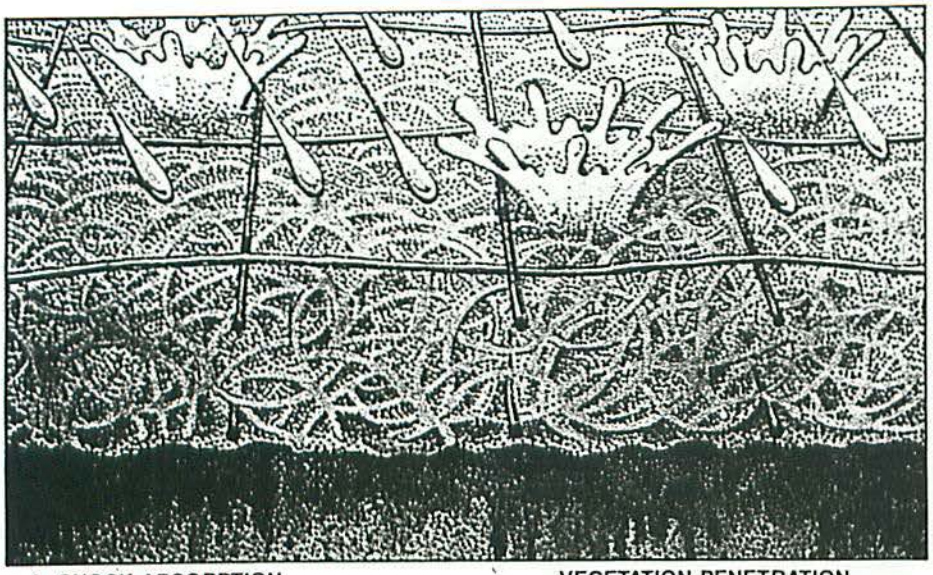
curlex blankets

WORKING WITH NATURE TO HELP CREATE A BETTER ENVIRONMENT



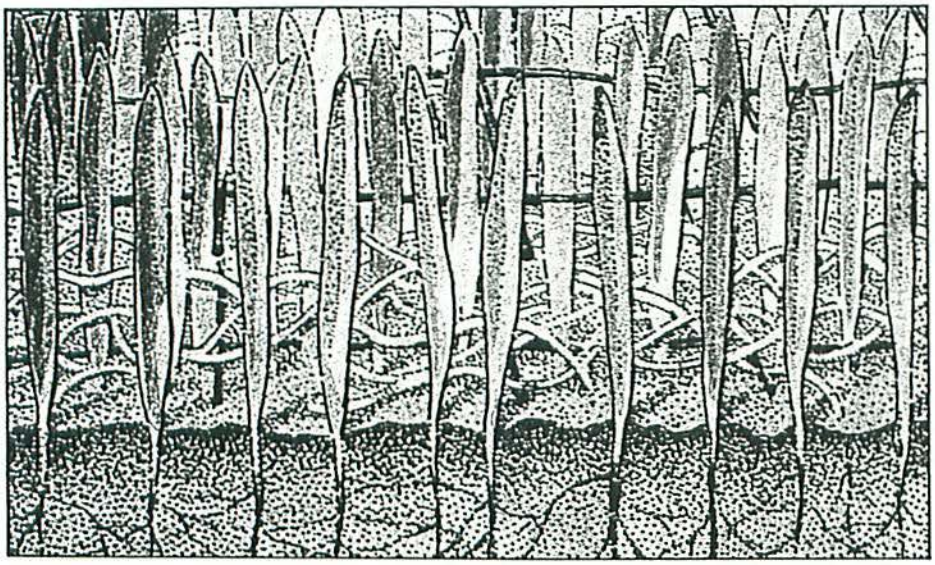
PROVEN PERFORMANCE IN EROSION CONTROL

Curlex Blankets



SHOCK ABSORPTION
The dense mat of curlex fibers and plastic netting arrests the destructive energy of rain drops, holds soil and seed in place and helps establish vegetation.

VEGETATION PENETRATION
Vegetation growing through the curlex matting helps anchor the mat in place, with each blade of grass becoming another anchor point.



Now you can prevent erosion, assist in germination and protect seedlings with AMXCO Curlex Blankets.

Curlex Blankets combine a dense mat of curled and seasoned Aspen wood excelsior with a tough, photo-degradable plastic mesh. They are designed to halt erosion and will remain in place on even the roughest terrain.

Hi-Velocity Curlex Blankets are specially made for use in situations of high-velocity water flow on slopes and in ditches.

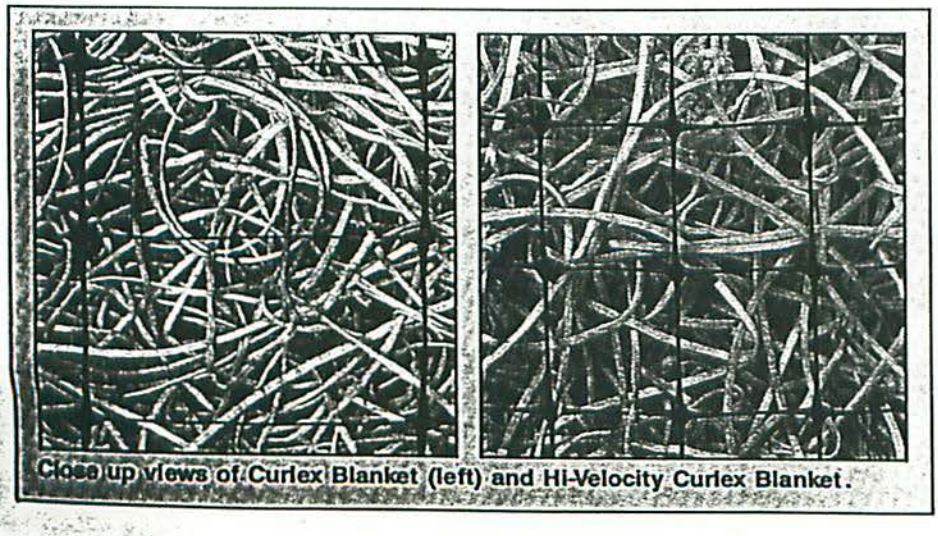
Curlex Blankets provide the ideal ground conditions for fast turf development. When properly installed, they retain moisture, control surface temperature fluctuations of the soil, conform to the terrain, protect against sun burnout and break up rain drops to stop erosion.

Installation is uncomplicated and instructions are clear so that inexperienced labor can apply Curlex Blankets.

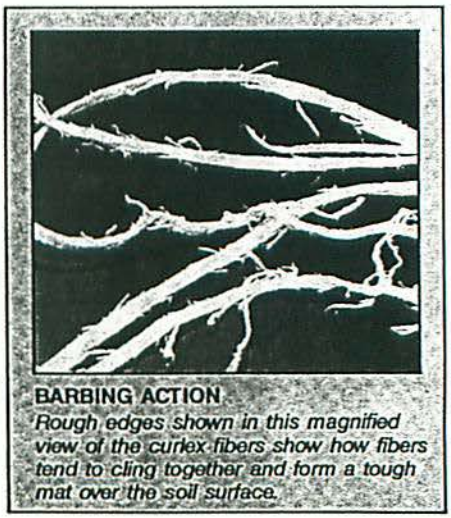
Uses and Application

Curlex Excelsior Blankets are designed to prevent erosion on:

- Steep slopes
- Berms
- Median strips
- Mine tailing sites
- Ditches
- Strip mine sites
- Ski slopes
- Dam sites
- Dikes
- Landscape projects or any other "hard to hold" problem area.

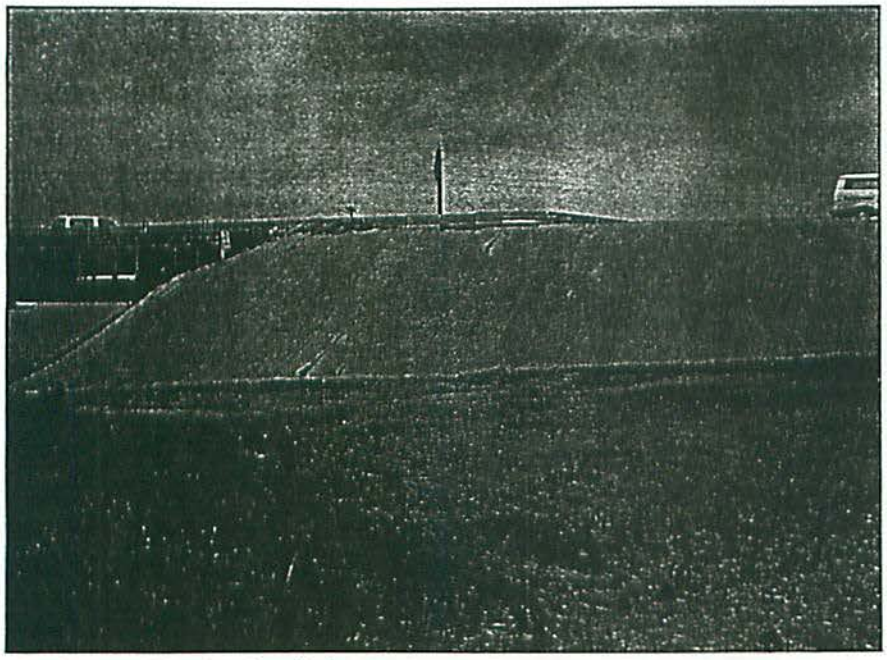


Close up views of Curlex Blanket (left) and Hi-Velocity Curlex Blanket.

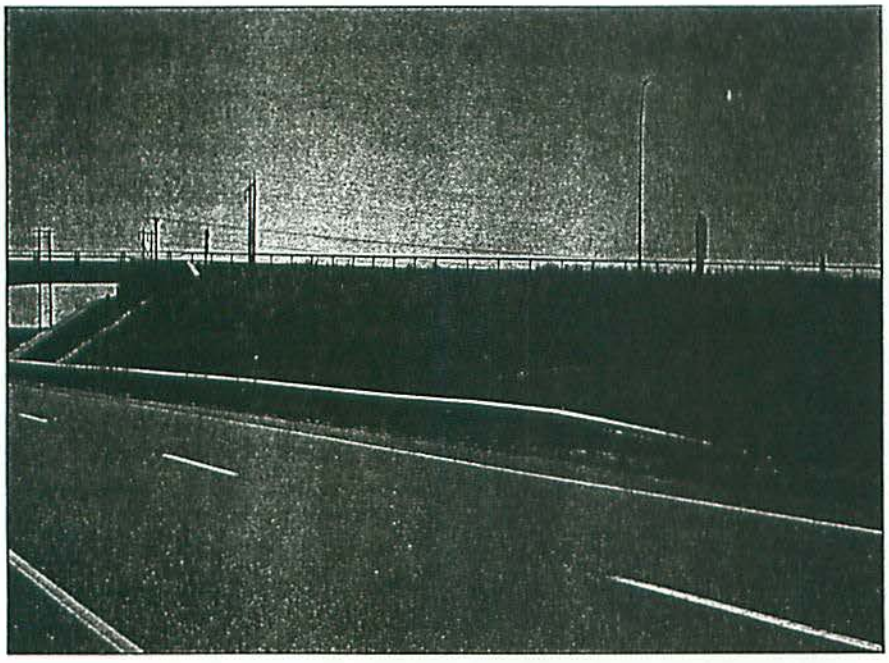


BARBING ACTION
Rough edges shown in this magnified view of the curlex fibers show how fibers tend to cling together and form a tough mat over the soil surface.

Curlex Blankets



Wyoming roadside slope installation.



The Excelsior Curlex Blanket is a machine-produced mat of curled wood excelsior of 80% six-inch or longer fiber length. It has a consistent thickness, with the fiber evenly distributed over the entire area of the blanket. The top side of each blanket is covered with a photodegradable extruded plastic mesh. The blanket is smolder-resistant without the use of chemical additives.

Installation Instructions

Properly prepare, fertilize and seed area to be covered before blanket is applied. When the blanket is unrolled, netting should be on top and fibers in contact with the soil over the entire area. In ditches, apply blankets in the direction the water flows, butting them at the ends and sides and then stapling. On slopes, apply blankets either horizontally or vertically to slope, butt ends and sides and then staple. It is not necessary to dig check slots, anchor ditches or bury ends of blankets unless called for in design specifications.

ROLL SIZE

Width	48 in. (+/– 1 in.)
Length	180 ft. average
Weight Per Roll	78 lbs. (+/– 10%)
Square Yards Per Roll	80 average

INST/
APPLIC/

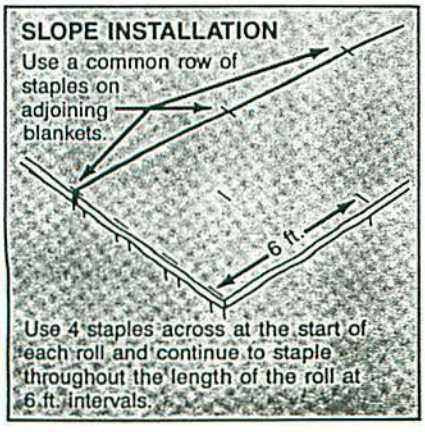
Curlex Blankets 3:

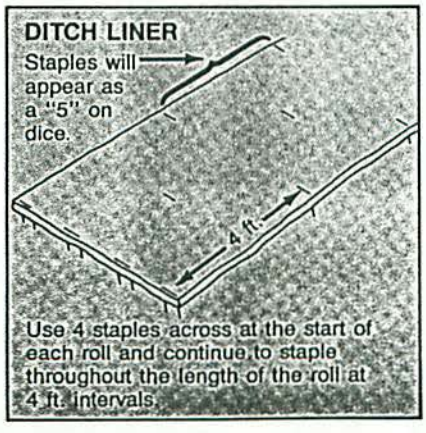
1 man crew—80
2 man crew—18
3 man crew—32

Hi-Velocity Curlex

1 man crew—88
2 man crew—19
3 man crew—35

Application rate figure
inexperienced labor u





Stapling Instructions for AMXCO Curlex Blankets

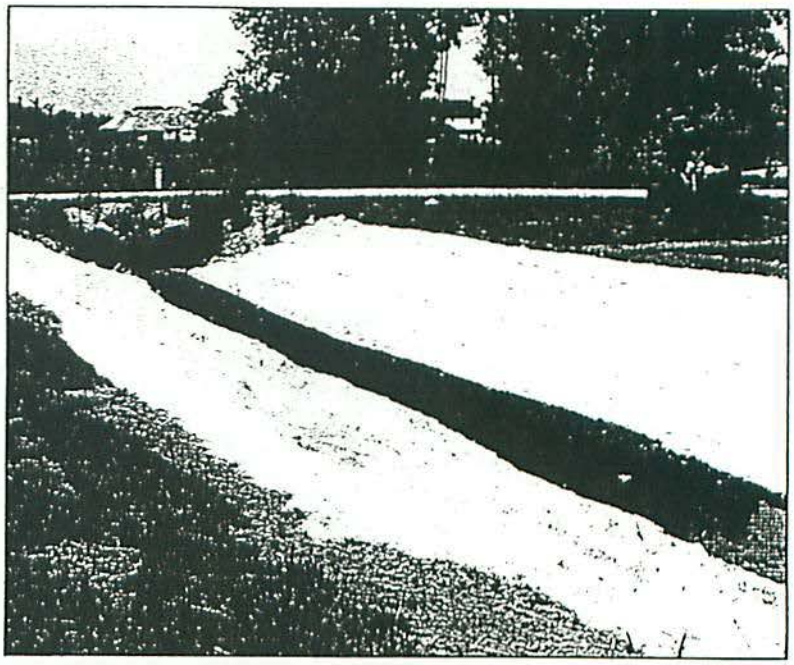
Use wire staples, .091" in diameter or greater, "U" shaped with legs 6" in length and a 1" crown. Size and gauge of staples used will vary with soil conditions. Drive staples vertically into the ground. Use four staples across at the start of each roll. For slope installation, continue to staple along the length of the roll at 6 ft. intervals. For ditch liner, staple along the length of the roll at 4 ft. intervals. Another row of staples in the center of each blanket should be alternately spaced between each side for either slope or ditch. Use a common row of staples on adjoining blankets.

Hi-Velocity Curlex Blankets

Designed to control erosion in areas of high-velocity water runoff, the Excelsior Hi-Velocity Curlex Blanket is a machine-produced mat of curled wood excelsior of 80% six-inch or longer fiber length, with consistent thickness and fiber evenly distributed over its entire area. Each side is covered with black, extra heavy-duty extruded plastic mesh netting designed to last for years and reinforce the root system after the excelsior mat has decomposed. They are smolder-resistant—no chemical additives.

Installation Instructions

This blanket is designed to withstand high-velocity water movements in ditches and on slopes. In ditches, unroll blanket in direction of water flow. When using two blankets side by side in a ditch, do not put the seams in the center of the ditch. Offset by 6 inches to 1 foot. On slopes, start blanket 3 feet over crest of slope or dig anchor ditches if specified. Blankets may be installed horizontally or vertically, whichever is easier.



Hi-Velocity ditch liner application in Midwest.

HI-VELOCITY ROLL SIZE

Width	48 in. (+/– 1 in.)
Length	100 ft. min.
Area Coverage	400 sq. ft. (44 + sq. yds.)
Weight	72 lbs. (+/– 7 lbs.)

ALLATION
ATION RATES

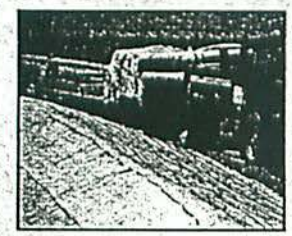
Slope

) sq. yards per man/hr.
0 sq. yards per man/hr.
sq. yards per man/hr.

Blankets 3:1 Slope

3 sq. yards per man/hr.
sq. yards per man/hr.
50 sq. yards per man/hr.

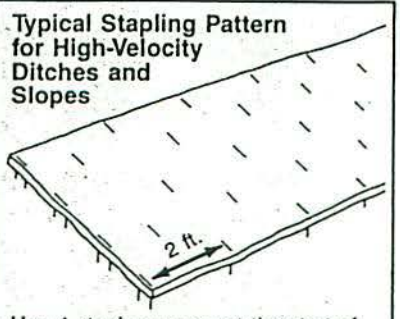
are based on
ng 6" wire staples.



Stapling Instructions for AMXCO Hi-Velocity Curlex Blankets

Use wire staples, .091" in diameter or greater, "U" shaped with legs 8" long or longer and 1" to 2" crown. Size and gauge of staples used will vary with soil types. Use four staples across at the start of each roll and continue to staple along the length of the roll at 2 ft. intervals. When blankets are placed alongside each other, staple so as to catch the edge of each roll. In addition to stapling the edges of the blanket at the appropriate intervals (see drawing), place staples in the center of the blanket halfway between the outer staples.

Typical Stapling Pattern for High-Velocity Ditches and Slopes



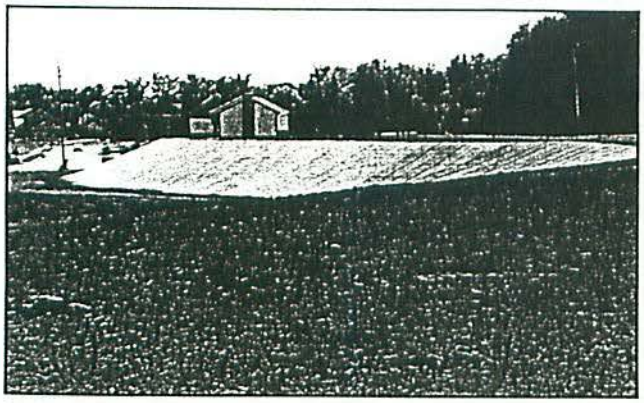
Use 4 staples across at the start of each roll and continue to staple throughout the length of the roll at 2 ft. intervals.

Hi-Velocity Curlex Blankets
are recommended for the following water velocities:

Soil Types	Velocity/Feet Per Second
Clay, clay loam, silty clay	11 FPS
Clay, silty clay, sandy clay loam	9.8 FPS
Fine sandy loam, silty loam	8.6 FPS

These figures are based on ditch lining at over 3% grade up to 13%. On slope protection, the determining factor would be the grade of the slope, berms above and sheeting effect of water velocity.

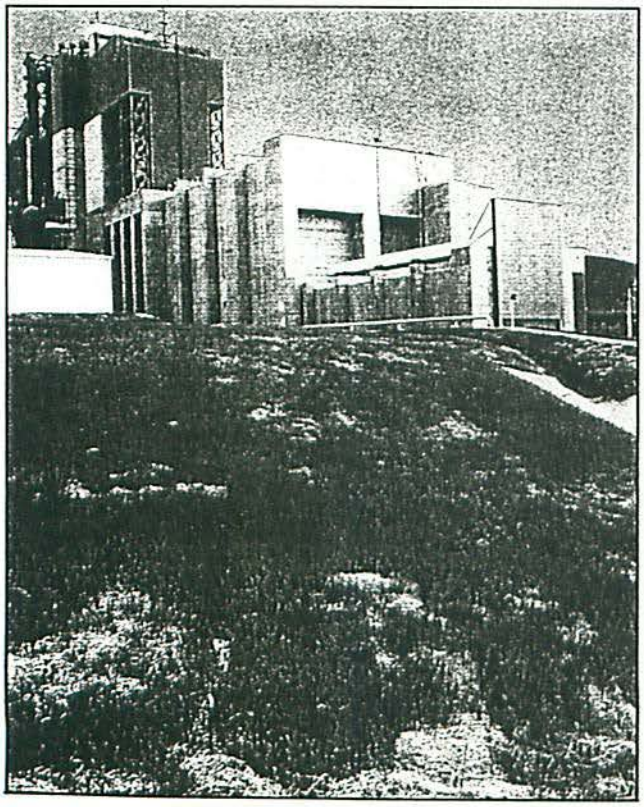
Various Applications



Curlex Blankets prevent erosion on steep slope at a residential housing development.

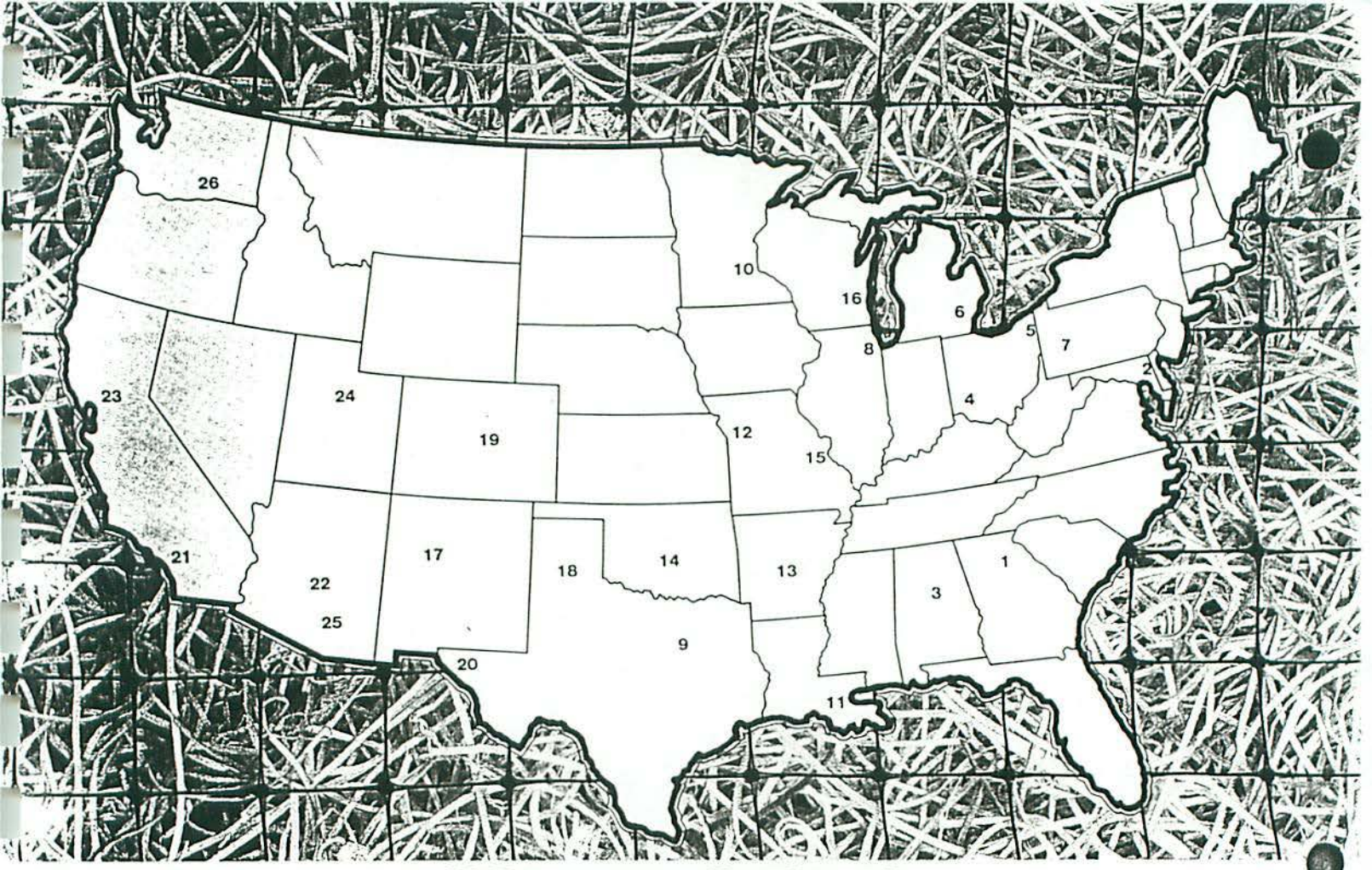
This application was done for the U.S. Forest Service at an altitude of 12,000, near Meteetse, Wyoming.

At this site in Alaska, Curlex Blankets are used in conjunction with gabion to prevent erosion on a hillside.



Curlex Blankets prevent erosion and establish vegetation at a missile site.

A roadside slope application



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(800) 658-5933

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(800) 228-0729

American Excelsior Company

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— With 26 Locations Across The U.S. —

6-94-021

American Excelsior Company
AN EMPLOYEE OWNED COMPANY

SUPER 8' WIDE

CURLEX®

EROSION CONTROL BLANKET

SPECIFICATIONS: *The SUPER 8' WIDE* ***Curlex®*** *Excelsior Blanket is a machine-produced mat of curled wood excelsior of 80% six-inch or longer fiber length. It has a consistent thickness, with the fiber evenly distributed over the entire area of the blanket. The top side of each blanket is covered with a photodegradable extruded plastic mesh. The blanket is smolder-resistant without the use of chemical additives.*

ROLL SIZE:

WIDTH	8 FOOT (+/- 1 INCH)
LENGTH	90 FOOT MINIMUM
WEIGHT PER ROLL	72 LBS. (+/- 10%)
SQUARE YARDS PER ROLL	80 MINIMUM

INSTALLATION INSTRUCTIONS: *Properly prepare, fertilize and seed area to be covered before blanket is applied. When the blanket is unrolled, netting should be on top and fibers in contact with the soil over the entire area. In ditches, apply blankets in the direction of the water flow, butting them at the sides and "shingling" at the ends and then stapling. On slopes, apply blankets either horizontally or vertically to slope, butt sides and "shingle" ends and then staple. It is not normally necessary to dig check slots, anchor ditches or bury ends of blankets, unless called for in specific design specifications. Detailed "Site Specific" installation instructions can be obtained from a qualified* ***American Excelsior Company*** *Erosion Control Products Representative, or by obtaining our detailed* ***CURLEX®*** *BLANKET INSTALLATION SPECIFICATIONS MANUAL from the Yakima, WA office by calling us Toll-Free @* ***1-800-228-0729.***

FOR ADDITIONAL INFORMATION

CONTACT: Phil Davis
Erosion Control Specialist

American Excelsior Company
609 S. Front St.
Yakima, WA 98901

CALL TOLL-FREE: **1-800-228-0729**